Zeus^{IOPS} Fibre Channel 3.5-Inch Solid State Drive Product Manual

61000-04522-101: Revision 1.6

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CONVENTIONS

The following icons are used throughout this document to identify additional information of which the reader should be aware.

SHOCK HAZARD: This icon indicates the danger of an electrical shock that may harm or otherwise prove fatal to the user.

CAUTION: This icon indicates the existence of a hazard that could result in equipment or property damage or equipment failure if the safety instruction is not observed.

ELECTROSTATIC DISCHARGE: This icon indicates the possible presence of Electrostatic Discharge (ESD or “static electricity”) that may harm the internal electronic components. The user is advised to handle the device only after discharging any possible electrostatic buildup that may be present.

NOTE: This icon identifies information that relates to the safe operation of the equipment or related items.

TIP: This icon identifies helpful hints and tips.

REVISION HISTORY

Revision Status Summary Sheet

Revision	Date	Sheet(s) Affected
0.1	11/30/2006	All. Initial release.
1.0	02/16/2007	Official release.
1.1	03/20/2007	Page 60: Corrected commercial case temperature range in Table 34; Page 60: corrected storage temperature range in Table 35; Pages 62 - 63: Added Relative Humidity, Altitude Parameters, Shock and Vibration, Failure Criteria, Operating Shock and Vibration and Drop Testing data.
1.2	05/11/2007	Page 19: Added "SMART Specification" topic to Overview section. Also added "SMART Specification" section to product datasheet.
1.3	06/11/2007	Updated all references to dimensions and dimensioned illustrations to reflect new assembly.
1.4	06/25/2007	Title Page, Page 17: Updated artwork to "RoHS Compliant" label. Updated pages 79, 87 and 88 to reflect the use of "6-32" screws, instead of "M3" screws for mounting requirements.
1.5	08/03/2007	Page 17: Updated Table 1, "Product ID Codes" to reflect the manufacture of RoHS Compliant, lead-free products. Page 69: Minor corrections to Table 36, "Storage Capacities" Page 90: Updated "Ordering Information" matrix to reflect manufacture of RoHS Compliant, lead-free products.
1.6	10/10/2007	Pages 34 - 59: Added the following commands to the SCSI Commands section: Format Unit, Reassign Blocks, Mode Select (6), Start/Stop Unit, Receive Diagnostic Results, Send Diagnostic, Write Buffer, Read Buffer, Read Long (10), Write Long (10), Read Defect Data (10 and 12), Write Same, Log Select, Log Sense, Mode Select (10) and Mode Sense (10).

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SCOPE

Figure 1. *The Zeus^{IOPS} Fibre Channel Solid State Drive*

OVERVIEW

This product manual describes the applications, specifications, and installation of the Zeus^{IOPS} 3.5-Inch Fibre Channel Solid State Drive (SSD). *See Figure 1*.

AUDIENCE

This document is intended for system engineers or system designers employed by an Original Equipment Manufacturer (OEM). This document was therefore written specifically for a technically advanced audience; it is not intended for end-users that will eventually purchase the commercially available product. The *user*, as referenced throughout this document, is primarily concerned with industrial, commercial or military computing applications.

CAUTION: This device can be damaged by Electrostatic Discharge (ESD). When handling the device, always wear a grounded wrist strap and use a static dissipative surface.

Any damage to the drive that occurs after its removal from the shipping package and ESD protective bag is the responsibility of the user.

STANDARDS AND REFERENCE DOCUMENTS

This section discusses the formal standards that may apply to the SSD, including electrical product standards. In addition, this section lists reference documents relevant to the FC-AL and FCP-SCSI protocols used for the SSD.

ELECTROMAGNETIC SUSCEPTIBILITY

The SSD is intended for installation by the user in an appropriate enclosure, i.e., a server or alternate enclosure. The enclosure must be designed so that the use of the drive does not impair nearby electronic equipment within the same enclosure and external to the enclosure.

The user is responsible for choosing, designing and testing the enclosure so that it is appropriate as previously defined, and complies to related regulations, such as Subpart B of Part 15 of FCC Rules and Regulations, and the Radio Interference Regulations of the Canadian Department of Communications.

REFERENCE DOCUMENTS

The following list of ANSI Fibre Channel documents relate to the SSD:

X3.230-1994	FC Physical and Signaling Interface (FC-PH)
X3.297.1997	FC-PH-2 Fibre Channel Physical and Signaling Interface-2
X3.303.1998	FC-PH-3 Fibre Channel Physical and Signaling Interface-3
X3.272-1996	FC Arbitrated Loop (FC-AL)
X3.269-1996	Fibre Channel Protocol for SCSI (FCP)
INCITS TR-19	Private Loop SCSI Direct Attach (PLDA)
INCITS TR-20	Fabric Loop Attachment (FC-FLA)
SFF-8045	40-pin SCA-2 Connector with Parallel Selection Specification
SFF-8067	40-pin SCA-2 Connector with Bidirectional Enclosure Services Interface Specification

The following list of ANSI SCSI documents relate to the SSD:

X3.131-1994	SCSI-2
X3.270-1996	SCSI-3 Architecture Model
INCITS 305-199X	SCSI-3 Enclosure Services

PRODUCT DESCRIPTION

GENERAL DESCRIPTION

The Zeus^{IOPS} Fibre Channel Solid State Drive (SSD) is a solid-state, non-volatile mass storage device. The interface is fully SCSI compliant and conforms to the same mechanical and mounting requirements as a rotating disk drive, and can be used as a replacement for a standard SCSI-compliant hard disk drive (HDD). The drive can be configured as a boot or data storage device.

FIBRE CHANNEL INTERFACE

The SSD can be installed in any operating system environment that supports FCP-4 devices. The Fibre Channel Protocol (FCP) is a method for transmitting SCSI commands and data over FC-FS-2 Exchanges and Information Units. It is a high-speed serial architecture that allows for connections over optical or electrical cable. It also supports fabric-switched and arbitrated-loop network topologies.

DRIVE CAPACITIES

The SSD is available in unformatted memory capacities of 18, 36, 73 and 146 gigabytes. The memory consists of Single-Level Cell (SLC) NAND EEPROM flash components.

PERFORMANCE

The SSD can operate at sustained data transfer rates of up to 200 megabytes per second. The drive is capable of performing 50,000 random operations per second. Power consumption is kept to a minimum; the SSD can be powered from a single 12-volt source. The solid state design eliminates electromechanical noise and delay inherent in traditional magnetic rotating media. The wear-leveling and bad-block mapping algorithms ensure consistency, accuracy, and integrity of user data. Superior data reliability is achieved through embedded Error Detection Code and Cyclic Redundancy Checking (EDC/CRC).

DATA SECURITY

The SSD offers erase and data sanitization (purge) features. Erase times vary according to the capacity of the drive. The drive can also be “sanitized”, thereby making data recovery impossible. See *Erase Times* and *Sanitize*.

PERFORMANCE CHARACTERISTICS

ENDURANCE

The useful life of the flash media is limited by the number of write/erase operations that can be performed on the media. To extend the life of the SSD, special Wear-Leveling and Bad-Block Mapping algorithms are integrated into the firmware.

WEAR-LEVELING ALGORITHM

The dynamic wear-leveling algorithm guarantees that erase/write cycles are evenly distributed across all the flash memory block locations. Wear-leveling eliminates repeated writes to the same physical flash memory location, thereby preventing blocks from premature wear.

BAD-BLOCK MANAGEMENT

The bad-block management scheme will detect faulty blocks during operation. Bad blocks are flagged in a defect list. Blocks within the defect list are excluded and are never used for data storage.

DATA RETENTION

Data stored on the SSD will remain valid for ten years without requiring power support. The unit can be stored at under certain environmental conditions for extended periods without any occurrence of data degradation.

ERROR DETECTION AND CORRECTION

The Error Detection Code and Error Correcting Code (EDC/ECC) algorithm helps maintain data integrity by allowing single or multiple bit corrections to the data stored in the flash array. If the data in the flash array is corrupted due to aging or during the programming process EDC/ECC will compensate for the errors to ensure the delivery of accurate data to the host computer. The EDC/ECC engine on the drive is capable of correcting 8 random or 12 sequential bytes in 1,024 bytes. The possibility of undetected errors or incorrect correction is eliminated with additional CRC.

RELIABILITY

- DC power is maintained as specified in the product datasheet.
- Errors caused by host are excluded from rates.
- Errors from the same causes are counted as 1 block.
- Data stream is assumed random.

MOUNT TIME

The amount of time required to initialize and mount a SSD varies according to the operating system (Windows®, Linux®, etc.) and the storage capacity of the drive.

ACCESS TIME

The SSD has no moving read/write heads or rotating platters. The access time ranges from 20µsec to 120µsec. The actual access time may be affected by the operating system and the storage capacity of the drive.

DATA TRANSFER RATES

The data transfer rates of the SSD are outlined in *Table 1*. Access times are measured under nominal temperature and voltages from a representative sample of the drive. The access times are measured from receipt of last byte of the Command Descriptor Block (CDB) to the request for a Status Byte Transfer to the Initiator, excluding Connect/Disconnect.

Table 1. *Data Transfer Rates*

Parameter	Value	Units
Average Access	20 - 120	µsec
Average Latency	0	m/sec
Sustained Read	200	Megabytes/sec
Sustained Write	100	Megabytes/sec
Duplex Burst Read	400	Megabytes/sec
Duplex Burst Write	400	Megabytes/sec
Minimum Sector Interleave	1:1	

Erase Times

The time required to erase the SSD varies according to the total capacity of the drive. The Erase utility will erase every physical memory storage location that can be accessed by the host interface. It will also destroy any saved messages. Once initiated, the SSD will be offline and the host will be unable to access the drive. Once the erase operation is completed the SSD will be restarted. If power ceases during an erase operation, the operation will be restarted when power is restored. *See Table 2*.

Table 2. *Erase Times*

Capacity	Erase Time
18 GB	30 sec
36 GB	60 sec
73 GB	120 sec
146 GB	240 sec

Sanitize

For sensitive data that requires more stringent security measures, the SSD is designed to comply with industry-standard data protection methods. The SSD will support the sanitize standards as detailed in DoD 5220.22-M, AFSSI 5020 and NSA 130-2. The Sanitize feature will erase every physical memory storage location and then will write data patterns to all possible NAND locations that are accessible to the host system. It will also destroy any saved messages. The time required to sanitize a SSD varies according to the drive capacity and the sanitize type. Each sanitize type requires different levels of erase/write cycles. If power is lost during this operation, the operation will be restarted when power is restored. *See Table 3*.

Table 3. *Sanitize Times and Standards*

Standard	DoD 522.22-M	AFSSI 5020	NSA 130-2
Capacity	Minutes	Minutes	Minutes
18 GB	6	6	18
36 GB	12	12	36
73 GB	24	24	72
146 GB	48	48	144

HOT PLUGGING

The SSD can be inserted or removed to and from a loop during operation. This capability is known as “hot plugging”. Fibre Channel error recovery procedures will recover from any errors introduced by hot plugging. Whenever a drive is hot plugged, sync is detected lost due to the removal or insertion of the drive into the loop.

The loop will recover as follows:

1. If a bypass circuit is used, the loop will re-synchronize and is operational while the user waits for the drive to power up and become ready. If a bypass circuit is not used, the loop loses synchronization and is not operational during this time.
2. When the drive becomes ready, and the bypass circuit (if used) is disabled, the drive will re-synchronize with the loop. It will synchronize with the device that is currently transmitting data to the SSD. All devices then go through loop initialization.
3. After the loop initializes, the loop is in monitoring state and arbitration of ownership can occur.

REPAIRS

A defective SSD should be replaced. There are no parts, assemblies or subassemblies that can be repaired by the user. Please see the section titled *Certification and Warranty* on the inside of the back cover page. *Unauthorized repairs to the SSD will void the warranty*.

PREVENTATIVE MAINTENANCE

No preventative maintenance is required. The SSD unit is sealed at the factory, and there are no parts, assemblies or subassemblies that require preventative maintenance on behalf of the user. Please see the section titled *Certification and Warranty* on the inside of the back cover page. *Unauthorized maintenance to the SSD will void the warranty*.

ELECTRICAL SPECIFICATIONS

POWER SUPPLY

The following voltage specification applies to the drive power connector. Connections to the drive should be made in a safety extra low voltage (SELV) circuit.

The drive *does not use* the +5V supply input pins available on a typical 40-Pin SCA-2 connector. The drive uses the +12V supply input. The 5V ground pins are connected to the common ground plane within the unit.

Adequate secondary over-current protection must be incorporated in the host system (drive enclosure, backplane, etc.). A 10 amp limit is required for safety purposes.

To avoid damage to the drive, power supply voltage transients must not exceed 16 volts.

POWER REQUIREMENTS

The SSD requires a 12V +/-10% DC power source. If a power failure occurs, the drive design ensures that the data contained in the storage memory is preserved. Data loss or corruption does not occur.

Table 4. *SSD Power Requirements*

Item	Requirement
Input Voltage	12V +/-10%
Minimum Voltage	10.8
Maximum Voltage	13.2

POWER CONSUMPTION

Table 5. *SSD Typical Power Consumption*

Activity	Average Current (mA)	Average Power (W)
Startup	1,200	14.4
Idle	450	5.4
Max Read @ 200MB/sec	700	8.4
Max Write @ 100MB/sec	675	8.1
Read, 1 Block Random I/O @ > 50,000	525	6.3
Write, 1 Block Random I/O @ > 18,000	660	7.9

GROUNDING

Signal and chassis ground are not connected together in the drive. To ensure minimal EM emissions, the user should provide maximum surface contact area when connecting the drive to chassis ground.

FAULT LED OUT SIGNAL

The Fault LED Out signal is driven by an open collector driver capable of sinking 30mA. It is driven low when an internal fault is detected along with both Enable Bypass signals.

READY LED OUT SIGNAL

The Ready LED Out signal is driven by an open collector driver capable of sinking 30mA. It will typically be connected to the cathode of an LED in the enclosure. The Ready LED function is nearly identical to the SFF-8045 specification for hot-plugging implementations; however, since the drive has no motor, it behaves as follows:

- Drive not mated:
  The signal is de-asserted (i.e., High). The LED is off.
- Drive mated, power-up diagnostics in progress:
  The signal is asserted for 1/3 of a second and de-asserted for 2/3 of a second. This represents a *1Hz Short flash*.
- Drive mated, firmware running, drive in progress of becoming ready:
  The signal is asserted for one-half second and de-asserted for one-half second. This represents a *1Hz Normal flash*.
- Drive mated, firmware running and drive ready:
  The signal is asserted when either of the loops is brought up. The signal will de-assert when the drive is active on either of the fibre loops.

-PARALLEL ESI AND SEL_*n*/P_ESI_*n*

SEL_*n*/P_ESI_*n* are a set of dual purpose pins that are used to convey either a Loop Identifier address or Enclosure Service Information (where this is supported by the backplane) to the SSD.

-Parallel ESI determines the function of Sel_*n*/-P_ESI_*n*. It is a TTL open-drain output from the SSD.

When -Parallel ESI is de-asserted (high), the backplane must present SEL_ID information on SEL_*n*/P_ESI_*n*. *See SEL_ID Function*.

When -Parallel ESI is asserted (low), the backplane must present Enclosure Service Information (if supported) on SEL_*n*/P_ESI_*n*. *See SEL_ID Function* on page 16.

Note: The maximum response time to a change in state of -Parallel ESI is 1µS.

SEL_ID Function

The SEL_*n* (TTL compatible) inputs (defined when -Parallel ESI is de-asserted) provide a binary value of a loop identifier to the drive. These seven (7) signals define 128 possible values and are directly translated into an 8 bit hard Arbitrated Loop Physical Address (AL_PA). Only AL_PAs with neutral disparity are valid values. The drive will attempt to acquire this hard AL_PA during the LIHA phase of the Loop Initialization Process (LIP). *Table 6* lists the SEL_ID/AL_PA translation in hexadecimal format.

NOTE: An AL PA value of 0x00 is not valid for an NL_Port. A SEL_ID of 0x7F will force the SSD to obtain a soft address.

Table 6. *SEL_ID to AL_PA Translation*

SEL_ID	AL_PA	SEL_ID	AL_PA	SEL_ID	AL_PA	SEL_ID	AL_PA
00	EF	20	B2	40	72	60	3A
01	E8	21	B1	41	71	61	39
02	E4	22	AE	42	6E	62	36
03	E2	23	AD	43	6D	63	35
04	E1	24	AC	44	6C	64	34
05	E0	25	AB	45	6B	65	33
06	DC	26	AA	46	61	66	32
07	DA	27	A9	47	69	67	31
08	D9	28	A7	48	67	68	2E
09	D6	29	A6	49	66	69	2D
A	D5	2A	A5	4A	65	6A	2C
B	D4	2B	A3	4B	63	6B	2B
C	D3	2C	9F	4C	5C	6C	2A
D	D2	2D	9E	4D	5A	6D	29
E	D1	2E	9D	4E	59	6E	27
F	CE	2F	9B	4F	56	6F	26
10	CD	30	98	50	55	70	25
11	CC	31	97	51	54	71	23
12	CB	32	90	52	53	72	1F
13	CA	33	8F	53	52	73	1E
14	C9	34	88	54	51	74	1D
15	C7	35	84	55	4E	75	1B
16	C6	36	82	56	4D	76	18

17	C5	37	81	57	4C	77	17
18	C3	38	80	58	4B	78	10
19	BC	39	7C	59	4A	79	F
1A	BA	3A	7A	5A	49	7A	8
1B	B9	3B	79	5B	47	7B	4
1C	B6	3C	76	5C	46	7C	2
1D	B5	3D	75	5D	45	7D	1
1E	B4	3E	74	5E	43	7E	NA
1F	B3	3F	73	5F	3C	7F	SOFT

P_ESI_*n* FUNCTION

The SEL_N (TTL compatible) inputs and outputs (defined when -Parallel ESI is asserted) provide an interface between the enclosure and the drive. *Table 7* summarizes the signals.

Table 7. *SEL_N/P_ESI_N Signal Definitions*

-Parallel ESI (High)	-Parallel ESI (Low)
Sel_0 (Input)	P_ESI_0 (Input)
Sel_1 (Input)	P_ESI_1 (Input)
Sel_2 (Input)	P_ESI_2 (Input)
Sel_3 (Input)	P_ESI_3 (Input)
Sel_4 (Input)	P_ESI_4 (Input)
Sel_5 (Input)	P_ESI_5 (Input)
Sel_6 (Input)	-EFW (Input)

SFF-8045 ENCLOSURE SERVICE INTERFACE

The SFF-8045 Enclosure Service Interface defines 7 bits of enclosure status. This status is read by the drive, and presented to the Initiator, upon receipt of appropriate Receive Diagnostic command. The definitions of the status bits are vendor specific. The drive will not interpret the status. The drive assumes -EFW is status and treats it as if does the other P_ESI_n signals.

-ENBL_BYP CH1 AND -ENBL_BYP_CH2

These two signals are TTL outputs from the drive and provide 4mA of sink capability. The signals are intended to control the state of the loop port bypass circuit on the backplane. The drive powers up with these signals turned off. It is assumed that the backplane will provide a 1K ohm pull-down resistor that will ensure the drive is bypassed on the loop when it is not present, or when it is powering up. The drive will attempt to enable itself on both loops after a successful power up.

START_n MATED

These signals are used to control the motor spin on rotating media drives. Because the SSD is a solid-state device and has no motor, these signals are ignored by the drive.

-DRIVE PRESENT

This signal is connected to the ground plane of the drive. The backplane can use this signal to detect the presence of the drive.

DEV_CTRL_CODE_X

The DEV_CTRL_CODE_2 through DEV_CTRL_CODE_0 signals provide a binary code to the drive to control functions such as FC link rate, Power Failure Warning (PFW) and Hard Reset. The control function is either identified by a code or a sequence of codes on the DEV_CTRL_CODE signals. *Table 8* lists the functions and the associated codes that use a decode value on the DEV_CTRL_CODE signals.

The Hard Reset function uses a sequence of values on the DEV_CTRL_CODE signals. The sequence is 5, 1, 3, 2, 3, 1 and 5. A drive detecting a valid Hard Reset sequence shall perform the equivalent of a power-on reset.

4.7K ohm pull-up resistors to 3.3V are provided on the drive for both DEV_CTRL_CODE_2, DEV_CTRL_CODE_1 and DEV_CTRL_CODE_0 to ensure that each signal is maintained in its high state unless a low is provided from the backplane.

Note: Please refer to the SFF-8045 Specification for more information.

Table 8. *DEV_CTRL_CODE_N Signal Definitions*

	DEV_CTRL_CODE_N		
Link Rate	CODE_2	CODE_1	CODE_0
1.0625 GHz	1	1	1
2.1250 GHz	1	1	0
Reserved	1	0	1
Reserved	1	0	0
Reserved	0	1	1
Reserved	0	1	0
Reserved	0	0	1
Power Failure Warning	0	0	0

SSD OPERATION

The is comprised of the following primary functional blocks: the SCA-2 interface connector, a Host FPGA, which contains a processor, NAND FPGA, NAND flash memory, and DRAM. Read/write data transfer requests are initiated by the host via the SCSI bus interface. Once received, the Host FPGA controller, under the direction of the microcontroller, processes the request.

The FPGA NAND flash controller interfaces with the NAND flash chips and sequences the data flow between the DRAM and flash.

It is the microcontroller that will initiate and monitor all activity within the controller, including the execution of the bad-block mapping and wear-leveling algorithms.

The controller will decode an incoming host command, and will configure the appropriate interrupts and status for the local microprocessor to handle various SCSI commands. For read and write transfer commands, there are hardware functions that minimize firmware overhead to enhance performance.

Read and Write commands have dedicated hardware functions that do not require firmware support, thereby increasing performance. Some commands may require the host controller to use external circuitry that do not involve the flash memory controller. When a Read or Write operation is requested, the integrated DMA controllers transfer the Fibre Channel frames to and from the SSD DRAM.

SCA-2 Interface Connector

The SSD is equipped with a 40-pin SCA-2 bus connector. The connector is located at the rear of the drive. DC power and bus traffic is supplied through a non-shielded I/O 40-conductor cable. *Figure 2* shows the location of Pins 1, 20, 21 and 40 relative to the connector housing. *See Connector Pinout*.

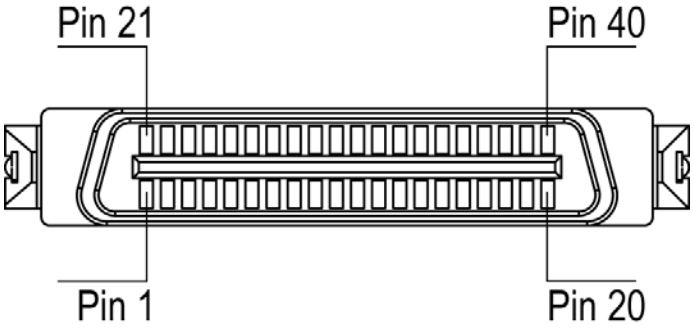


Figure 2. *SCA-2 Interface Connector*

Connector Location

Figure 3 shows the relative location of the SCA-2 connector on the rear of the SSD. Please note the location of Pin 1 relative to the connector.

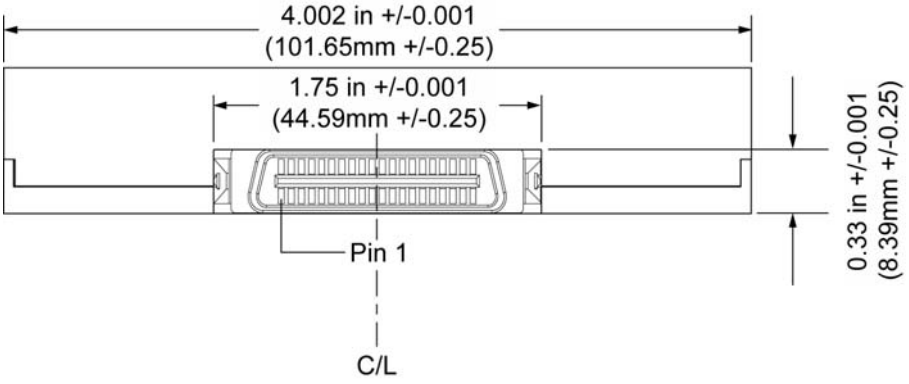


Figure 3. *Relative SCA-2 Connector Location*

CONNECTOR PINOUT

This section provides the pinout of the 40-pin SCA-2 connector, the pinout signal characteristics, and the use of the pinout signals with respect to the SSD. Refer to *Table 9* for the 40-pin SCA-2 connector pin-out.

Table 9. *40-Pin SCA-2 Connector Pinout*

Pin	Signal Name	Signal Type	Pin	Signal Name	Signal Type
1	-ENBL BYP CH1	Low Voltage TTL Output	21	12V Charge	
2	12 Volts		22	12V Ground	GND
3	12 Volts		23	12V Ground	GND
4	12 Volts		24	+Port 1_In	Differential PECL Input Pair
5	-Parallel ESI		25	-Port 1_In	
6	-Drive Present	GND	26	12V Ground	GND
7	Ready LED Out	Open Collector Out	27	+Port 2_In	Differential PECL Input Pair
8	Power Control		28	-Port 2_In	
9	Start_1/Mated	TTL Input	29	12V Ground	GND
10	Start_2/Mated	TTL Input	30	+Port 1_Out	Differential PECL Output Pair
11	-ENBL BYP CH1	Low Voltage TTL Output	31	-Port 1_Out	
12	SEL_6/-EFW	TTL Input/Output	32	5V Ground	GND
13	SEL_5/-P_ESI_5	TTL Input/Output	33	+Port 2_Out	Differential PECL Output Pair
14	SEL_4/-P_ESI_4	TTL Input	34	-Port 2_Out	
15	SEL_3/-P_ESI_3	TTL Input/Output	35	5V Ground	GND
16	Fault LED Out	Open Collector Out	36	SEL_2/-P_ESI_2	TTL Input/Output
17	DEV_CTRL_CODE_2	TTL Input	37	SEL_1/-P_ESI_1	TTL Input/Output
18	DEV_CTRL_CODE_1	TTL Input	38	SEL_0/-P_ESI_0	TTL Input/Output
19	5 Volts		39	DEV_CTRL_CODE_0	TTL Input
20	5 Volts		40	5 Volts Charge	

VOLTAGE AND GROUND SIGNALS

The 12V contacts provide all the power required by the drive. The 5V Charge and 5 Volt contacts are not used. All 5V ground and 12V ground contacts are connected to the drive ground plane.

LOOP CONNECTIONS

The SSD features two independent FC-AL ports. These ports may be connected in different loops or the same loop. In addition, the drive can send transfers while receiving frames on both ports. This capability is called “full-duplex”. The following scenarios may apply:

1 If the ports are 1) connected in different loops, 2) hard addressing is used, and 3) the drive interface address is selected through the interface connector, then both ports will seek the same loop address. If there are no duplicate addresses on the different loops, both ports will use the same address.

2 If the ports are 1) connected in the same loop and 2) hard addressing is used, the drive reads the settings from the connector. If the SCA connector is configured for a hard address, only one of the ports will be seen on the loop; only one port can acquire the ID.

3 If the drive has 1) its ports connected to different loops, and 2) buffer availability, then the drive is able to receive transfers on both ports at the same time. This capability is called “concurrent port transfers”.

Table 10 summarizes the FC-AL options supported by the drive.

Table 10. *FC-AL Supported Options*

Option	Support
OPEN Half Duplex	Accepted from another device
OPEN Full Duplex	Sent to open another device; accepted from another device
Private Loop	Supported
Public Loop	Supported
Old Port State	Not supported
Loop Position	Supported
Loop Position Report	Supported

FCP-SCSI COMMANDS

SUPPORTED SCSI COMMANDS

Table 11 summarizes the SCSI commands supported by SSD. Command queuing is supported with all tag types (Head of Queue, Ordered Queue and Simple Queue). A maximum of 256 commands may be queued against each fibre channel port. This section only provides an overview of the SCSI commands supported by the SSD. For more information, please consult the SCSI specification, *Fibre Channel Protocol - 3 (FCP-3), Project T10/1560D, ANSI INCITS 416-2006*.

NOTE: Linked SCSI commands are not supported. NACA does not apply to the Fibre Channel standard. As a result, all the Control bytes of all the commands are ignored.

Table 11. *Supported SCSI Commands*

Command Code	Command Name
A0h	Report Luns
00h	Test Unit Ready
04h	Format Unit
07h	Reassign Blocks
08h	Read (6)
0Ah	Write (6)
12h	Inquiry Vital Product Data Page (00h) Unit Serial Number Page (80h) Device Identification Page (83h)
15h	Mode Select (6)
16h	Reserve (6). Obsolete, but supported.
17h	Release (6). Obsolete, but supported.
1Ah	Mode Sense (6)
1Bh	Start/Stop Unit
1Ch	Receive Diagnostic Results
1Dh	Send Diagnostic
4Ch	Log Select

4Dh	Log Sense
25h	Read Capacity
28h	Read Extended (10)
2Ah	Write Extended (10)
2Eh	Write and Verify (10)
2Fh	Verify (10)
3Bh	Write Buffer
3Ch	Read Buffer
3Eh	Read Long (10)
3Fh	Write Long (10)
35h	Synchronize Cache (10)
37h	Read Defect Data (10)
41h	Write Same
4Ch	Log Select
4Dh	Log Sense
55h	Mode Select (10)
5Ah	Mode Sense (10)
56h	Reserve (10). Obsolete, but supported.
57h	Release (10). Obsolete, but supported.
5Eh	Persistent Reserve In
5Fh	Persistent Reserve Out
B7h	Read Defect Data (12)

REPORT LUNS (A0h)

The REPORT LUNS command will request that the peripheral device logical unit inventory accessible to the I_T nexus be sent to the application client. The logical unit inventory is a list that shall include the logical unit numbers of all logical units having a Peripheral Qualifier value of 000b. Logical unit numbers for logical units with Peripheral Qualifier values other than 000b and 011b may be included in the logical unit inventory. Logical unit numbers for logical units with a Peripheral Qualifier value of 011b are excluded from the logical unit inventory. The SSD only appears as a single LUN (Logical Unit Number). Byte 2 and Byte 11 are ignored.

***Table 12.** Report Luns Command*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (A0h)							
1	Reserved							
2	Select Report							
3	Reserved							
5								
6	(MSB)							
9	Allocation Length							(LSB)
10	Reserved							
11	Control							

TEST UNIT READY COMMAND (00h)

The TEST UNIT READY command provides a method to check if the logical unit is ready. This is not a request for a self-test. If the logical unit would accept an appropriate medium-access command without returning CHECK CONDITION status, this command shall return a GOOD status. If the logical unit cannot become operational or is in a state such that an initiator action is required to make the unit ready, the target shall return CHECK CONDITION status with a sense key of NOT READY. Byte 5 is ignored..

Table 13. *Test Unit Ready CDB*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (00h)							
1	Reserved			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

FORMAT UNIT (04h)

The FORMAT UNIT (04h) command will request that the device server format the medium into application client-accessible logical blocks as specified in the number of blocks and block length values received in the last mode parameter block descriptor in a MODE SELECT command. The device server may certify the medium and create control structures for medium management and defects. The degree to which the medium is altered is vendor-specific.

Table 14. *Format Unit Command*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (04h)							
1	FMTPINFO	RTO_REQ	LONGLIST	FMTDATA	CMPLIST	DEFECT LIST FORMAT		
2	Vendor Specific							
3	Obsolete							
4								
5	Control							

Notes:

1 The FMTPINFO and RTO_REQ bits are not supported and the command is rejected if either of these bits are set.

2 The DCRT, FOV and STPF bits are ignored.

3 IF DPRY is set then all defects apart from the original defects listed by the NAND chip manufacturer are returned into use.

4 If format data is supplied, it is accepted by ignored. The drive then erases all user data from the device.

REASSIGN BLOCKS (07h)

This command is supported by the SSD to allow the operation of host systems that may use the REASSIGN BLOCKS command. However, the command cannot be truly supported because there is no direct correlation between a host block number and where data is stored on the media. The command can be issued and the data accepted, but the SSD will only return a “GOOD” status.

Table 15. *Reassign Blocks Command*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (07h)							
1	Reserved						LONGLBA	LONGLIST
2								
3	Reserved							
4								
5	Control							

READ (6) COMMAND (08h)

The READ (6) command requests that the drive transfer data to the initiator. The most recent data value written in the addressed logical block shall be returned.The logical block address field specifies the logical block at which the read operation shall begin. The transfer length field specifies the number of contiguous logical blocks of data to be transferred. A transfer length of zero indicates that 256 logical blocks shall be transferred. Any other value indicates the number of logical blocks that shall be transferred. Byte 5 is ignored.

Table 16. Read (6) CDB

	Bit									
Byte	7	6	5	4		3	2	1		0
0	Operation Code (08h)									
1	Logical Unit Number			(MSB)						
2	Logical Block Address									
3										(LSB)
4	Transfer Length									
5	Control									

WRITE (6) COMMAND (0Ah)

The WRITE (6) command requests that the target write the data transferred by the initiator to the medium. The logical block address field specifies the logical block at which the write operation shall begin. The transfer length field specifies the number of contiguous logical blocks of data to transfer. A transfer length of zero indicates that 256 logical blocks shall be transferred. Any other value indicates the number of logical blocks that shall be transferred. Byte 5 is ignored.

Table 17. Write (6) CDB

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (0Ah)							
1	Logical Unit Number (RSVD)			(MSB)				
2	Logical Block Address							
3								(LSB)
4	Transfer Length							
5	Control							

INQUIRY COMMAND (12h)

The INQUIRY command requests that information regarding parameters of the drive be sent to the initiator. Byte 5 is ignored. *See Tables 18 and 19*.

Table 18. *Inquiry CDB*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (12h)							
1	Logical Unit Number (RSVD)			Reserved				EVPD
2	Page Code							
3	Reserved							
4	Allocation Length							
5	Control							

An Enable Vital Product Data (EVPD) bit of one specifies that the drive return the optional vital product data specified by the page code field. If any optional fields in the CDB are set that the drive does not support, it will return a CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

An EVPD bit of zero specifies that the drive return the standard INQUIRY data. If the page code field is not zero, the target shall return CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB. The page code field specifies which page of vital product data information the drive returns.

The INQUIRY command shall return CHECK CONDITION status only when the target cannot return the requested INQUIRY data. The INQUIRY data should be returned even though the peripheral device may not be ready for other commands. If an INQUIRY command is received from an initiator with a pending unit attention condition, the drive will perform the INQUIRY command and not clear the unit attention condition.

Note: Please refer to the SCSI specification for further details on the vital product data pages and formats.

Table 19. *Standard Inquiry Data Format*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Peripheral Qualifier			Peripheral Device Type				
1	RME	Device-Type Modifier						
2	ISO Version		ECMA Version			ANSI-approved Version		
3	AEHC	TrmlOP	Reserved		Response Data Format			
4	Additional Length (n-4)							
5	Reserved							
6	Reserved							
7	RelAdr	Wbus32	Wb16	Sync	Linked	Reserve	CmdQu	SftRe
8	(MSB)	Vendor Identification						
15								(LSB)
16	(MSB)	Product Identification						
31								(LSB)
32	(MSB)	Product Revision Level						
35								(LSB)
36	Vendor-Specific							
55								
56	Reserved							
95								
	Vendor-Specific Parameters							
96	Vendor-Specific							
n								

MODE (6) SELECT (15h)

The MODE (6) SELECT (15h) command is used to change the device information contained in the mode pages of a target device. There is a 6-byte version and a 10-byte version. See also: *MODE (10) SELECT (55h)*.

Table 20. *Mode (6) Select (15h) Command*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (15h)							
1	Logical Unit Number (RSVD)			PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Parameter List Length							
5	Control							

The following MODE PAGES are supported:

Page	Description
0x00	Vendor-Specific. Please see the SMART Specification section in this manual.
0x01	Read/Write error recovery. All bits can be changed but only the PER bit is processed.
0x02	Disconnect/Reconnect. On the maximum burst size field (Bytes 10 and 11) can be changed.
0x07	Verify error recovery. All bits can be changed but only the PER bit is processed.
0x19	Fibre Channel Port Control. All bits can be changed but only the DTFD, DLM, RHA, ALWI and DTOL1 bits are processed.
0x1C	Informational Exceptions Control. Please see the SMART Specification section in this manual.

MODE (6) SENSE COMMAND (1Ah)

The MODE SENSE (6) command provides a means for a target to report parameters to the initiator. It is a complementary to the MODE SELECT (6) command.

Table 21. *Mode Sense CDB*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Ah)							
1	Logical Unit Number (RSVD)			Reserved		DBD	Reserved	
2	PC		Page Code					
3	Reserved							
4	Allocation Length							
5	Control							

A Disable Block Descriptors (DBD) bit of zero indicates that the target may return zero or more block descriptors in the returned MODE SENSE data, at the target's discretion. A DBD bit of one specifies that the target shall not return any block descriptors in the returned MODE SENSE data. The page control (PC) field defines the type of mode parameter values to be returned in the mode pages. The page code specifies which mode page to return.

Table 22. *Page Code Field Descriptions*

Page Code	Description	Subclause
00h	Vendor-specific (does not require page format)	
01h - 1Fh	See specific device-types	
20h - 3Eh	Vendor-specific (page format required)	
3Fh	Return all mode pages	

START/STOP UNIT (1Bh)

The Start/Stop Unit (1Bh) command is used to control the motor in a rotary device such as a hard disk drive, and load or eject removable media such as tapes or CD-ROMs. It is frequently issued after initial communication has been established between the initiator and target devices. However, the command is irrelevant to an SSD. No action occurs and the command returns a “GOOD” status.

Table 23. Start/Stop Unit (1Bh) Command

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Bh)							
1	Logical Unit Number (RSVD)			Reserved				Imme
2	Reserved							
3	Reserved							
4	Reserved						LoEj	Start
5	Control							

RECEIVE DIAGNOSTIC RESULTS (1Ch)

The RECEIVE DIAGNOSTIC RESULTS (1Ch) command will interrogate the results of a self-test that was initiated by a previous SEND DIAGNOSTIC command. However, the SSD only supports Page Codes 0x00 and 0x80. Page Code 0x80 is vendor-unique to STEC and is used to gather link error statistics.

Table 24. Receive Diagnostic Results CDB

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Ch)							
1	Logical Unit Number (RSVD)			Reserved				
2	Reserved							
3 - 4	Allocation Length							
5	Control							

Note: If any of the counters of the RECEIVE DIAGNOSTICS RESULTS Page 0x80 attain their maximum values, the values are maintained and will not wrap back to 0 (zero).

Table 25. *Receive Diagnostics Page 0x80*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2	(MSB	Page Length (009Eh)						
3								(LSB)
4-11	Vendor Identification (From Standard Inquiry Data)							
12-15	Product Revision Level (From Standard Inquiry Data)							
16-17	Number of Feature Descriptors (0001h)							
18-19	Feature ID (0000h)							
20-21	Feature Sub-ID (0000h)							
22	Reserved							
23-24	Number of Parameter Descriptors (0011h)							
25	Parameter Descriptor Size (08h)							
26-161	List of Parameter Descriptors							

Each Parameter Descriptor in Bytes 26 - 161 is an 8-byte field. *Table 26* defines the format.

Table 26. *Parameter Descriptor Format/Bytes 26 - 161*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Parameter ID (MSB)							
1	Parameter ID (LSB)							
2	Parameter Sub-ID (MSB)							
3	Parameter Sub-ID (LSB)							
4	Value [3] (MSB)							
5	Value [2]							
6	Value [1]							
7	Value [0] (LSB)							

In addition, the Parameter IDs and Sub-IDs can be combined to report the status of the various counts. *See Table 27*.

Table 27. *Parameter ID/Sub-ID Combinations*

Parameter ID	Parameter Sub-ID	Description	Comment
0	0	Command Initiate Port; 0 = Port A, 1 = Port B	Required
1	0	Port A Invalid Transmission Word Count	Required
1	1	Port B Invalid Transmission Word Count	Required
2	0	Port A Loss of Synchronization Count	Required
2	1	Port B Loss of Synchronization Count	Required
3	0	Port A Link Failure Count	
3	1	Port B Link Failure Count	
4	0	Port A Invalid CRC Count	
4	1	Port B Invalid CRC Count	
5	0	Port A LIP F8 Initiated Count	Required
5	1	Port B LIP F8 Initiated Count	Required
6	0	Port A LIP F8 Received Count	Required
6	1	Port B LIP F8 Received Count	Required
7	0	Port A LIP F7 Initiated Count	Required
7	1	Port B LIP F7 Initiated Count	Required
8	0	Port A LIP F7 Received Count	Required
8	1	Port B LIP F7 Received Count	Required

SEND DIAGNOSTIC (1Dh)

The SEND DIAGNOSTIC command is a six byte CDB. The Parameter List Length is two bytes (Bytes 2 and 4). Bytes 1 through 5 are ignored.

Table 28. *Send Diagnostics CDB*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (1Dh)							
1	Logical Unit Number (RSVD)			PF	Reserved	SelfTest	DevOfL	UnitOfL
2	Reserved							
3	(MSB)							
4	Parameter List Length							
5								(LSB)
6	Control							

Notes:

1 The PF bit is not supported and the command is rejected if this bit is set.

2 The Self-Test code bits are ignored.

3 The operation is dependent on the SelfTest, DevOfL and UnitOfL bits. See the following table.

SelfTest	DevOfL	UnitOfL	Result
1	0	1	Do long self test (< 90 secs)
1	1	0	Do short self test (< 2 secs)

READ CAPACITY (25h)

The READ CAPACITY command provides a means for the initiator to request information regarding the capacity of the logical unit. Bytes 1 through 9 are ignored. If Byte 8 is a non-zero, an illegal command will be returned.

Table 29. *Read Capacity CDB*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (25h)							
1	Logical Unit Number (RSVD)				Reserved			RelAdr

Table 29. *Read Capacity CDB*

2	(MSB)	
3	Logical Block Address	
4		
5		(LSB)
6	Reserved	
7	Reserved	
8	Reserved	PMI
9	Control	

READ (10) EXTENDED (28h)

The READ (10) EXTENDED (28h) command requests that the target transfer data to the initiator. The most recent data value written in the addressed logical block is returned. Byte 1 and Byte 9 are ignored.

Table 30. *Read Extended (10) CDB*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (28h)							
1	Logical Unit number (RSVD)			DPO	FUA	Reserved		RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	Transfer Length							(LSB)
9	Control							

WRITE EXTENDED (10) (2Ah)

The WRITE (10) EXTENDED (2Ah) command requests that the drive write the data transferred by the initiator to the medium. Bytes 1 and 9 are ignored.

Table 31. *Write Extended (10) (2Ah) CDB*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (2Ah)							
1	Logical Unit Number (RSVD)			DPO	FUA	Reserve	Reserve	RelAdr
2	(MSB)							
3	Logical Block Address							
4								
5								(LSB)
6	Reserved							
7	(MSB)							
8	Transfer Length							(LSB)
9	Control							

WRITE AND VERIFY (10) (2Eh)

The WRPROTECT field and DPO and BYTCHK bits in CDB Byte 1 are all ignored.

VERIFY (10) (2Fh)

The VRPROTECT field in Byte 1 is ignored. If the DPO and BYTCHK bits in CDB Byte 1 are not both zero, or the GROUP NUMBER field in Byte 6 is non-zero, the command is rejected. If any bit in Byte 1 is set other than LUN, or if any bits in Bytes 6 and 9, an Invalid field in the CDB is reported.

WRITE BUFFER COMMAND (3Bh)

The WRITE BUFFER command is complementary to the READ BUFFER command as a diagnostic function for testing logical unit memory in the SCSI target device and the integrity of the service delivery subsystem. Only Mode 2 (Data), Mode 5 (Download Microcode and Save) and Mode 7 (Download Microcode with Offsets and Save) are supported. For all supported modes the BUFFER_ID and CONTROL fields are not supported and must be set to 0 (zero) and the Allocation Length must be a multiple of 4 bytes with a maximum value of 2,097,152 (2 megabytes).

Table 32. Write Buffer Command (3Bh)

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (3Bh)							
1	Reserved			Mode				
2	Buffer ID							
3	(MSB)			Buffer Offset				
5								(LSB)
6	(MSB)			Parameter List Length				
8								(LSB)
9	Control							

The only mode fields supported are:

Mode	Value	Description
2	02h	Data. The OFFSET field is not supported and must be set to 0 (zero). Where the Allocation Length is greater than 4,096 the buffer will wrap with only the last 4K of data that was written being returned in response to the subsequent READ BUFFER command, though this data may be returned repeatedly. *See READ BUFFER 3Ch*.
5	05h	Download Microcode and Save. The OFFSET field is not supported and must be set to 0 (zero). Once the firmware has been downloaded and verified as correct will it be saved and the drive restarted.
7	07h	Download Microcode with Offsets and Save. As specified in the ANSI documentation.

READ BUFFER (3Ch)

The READ BUFFER (3Ch) command is complementary to the WRITE BUFFER command as a diagnostic function for testing logical unit memory in the SCSI device and the integrity of the service delivery subsystem. Only Mode 2 (Data) and Mode 3 (Descriptor) are supported. The BUFFER_ID, OFFSET and CONTROL fields are not supported and must be set to 0 (zero).

Table 33. *Read Buffer (3Ch) CDB*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (3Ch)							
1	Reserved			Mode				
2	Buffer ID							
3	(MSB)	Buffer Offset						
5								(LSB)
6	(MSB)	Allocation Length						
8								(LSB)
9	Control							

Notes:

1 The capacity of the buffer is 4,096 bytes. This is the length that is returned if the Descriptor mode is set (Mode 3).

2 If the Data mode is set (Mode 2), then command is rejected unless the Allocation Length is a multiple of 4 bytes. The maximum allocation length is 2,097,152 (2 megabytes).

3 If the allocation length is greater than 4,096, the buffer will wrap and the data that is returned is the last 4K that was written using the WRITE BUFFER command, repeated as many times as necessary.

READ (10) LONG (3Eh)

The READ (10) LONG (3Eh) command is used for ECC (Error Correcting Code) data that was written using the WRITE LONG command. The CORRECT bit is ignored and is always assumed to be set to 1. If an ECC error is detected, the data is ECC corrected if possible before being returned. The BYTE TRANSFER LENGTH must be set to 0x218 (536 bytes).

Table 34. Read (10) Long (3Eh) CDB

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (3Eh)							
1	Reserved						Correct	RelAdr
2 - 5	LBA							
6	Reserved							
7 - 8	Byte Transfer Length							
9	Control							

WRITE (10) LONG (3Fh)

The WRITE (10) LONG (3Fh) command is complementary to READ (10) LONG (3Eh). It allows for ECC (Error Correcting Code). The data sent by the initiator will include ECC fields with the data. The Byte Transfer Length field informs the target device the amount of data that is expected to be returned when the READ LONG command is used.

Table 35. Write (10) Long (3Fh) CDB

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (3Fh)							
1	LUN			Reserved				RelAdr
2 - 5	LBA							
6	Reserved							
7 - 8	Byte Transfer Length							
9	Control							

Note: The following restrictions apply to the WRITE LONG command:

1. The SSD calculates ECC over a 1K, rather than a 512 byte block. If a WRITE LONG command is issued to force ECC on a host block, it will force ECC to be required on two host blocks, e.g., a WRITE LONG on host block 0x1234 will also impact host block 0x1235; a WRITE LONG on host block 0x2345 will also impact host block 0x2344.
2. The Byte Transfer Length must be set to 0x218 (536 bytes).
3. It is recommended that the PER bit is set in MODE PAGE 1 when performing a READ LONG prior to a WRITE LONG so that a RECOVERED ERROR status is returned if the block in question already requires ECC correction. This prevents accidental hard ECC errors when testing ECC correction capabilities.
4. The WRITE LONG command will fail if an attempt is made to write to a block that has never been written to previously (since drive initialization) *and* a READ LONG has not be issued prior to the WRITE LONG command. The device will return SENSE KEY 0x03 (MEDIUM ERROR) additional sense code 0x12 (ADDRESS MARK NOT FOUND) under these conditions.

SYNCHRONIZE CACHE (10) (35h)

The Logical Block Address and Number of Blocks fields are checked to ensure that the fields are in range, but are then ignored and considered set to zero. All outstanding data is written out to the non-volatile memory. The SYNC_NV and IMMED bits in CDB Byte 1 are ignored.

READ (10) DEFECT DATA (37h)

The READ (10) DEFECT DATA (37h) command requests that the device server transfer the medium defect data to the Data-In buffer. Due to the solid-state design of the SSD, device defect data cannot be tied to a particular host block and there is no cylinder/head information. The Defect List Format field is ignored and the defect information is returned in a vendor-specific STEC format with each defect listed as being 8 bytes in length. For each defect the first four bytes will be zero and the next four will take the form of 0xCNNNNNXX, where C is the Channel Number, N is the NAND block number and X is Don't Care. The command also provides a method to determine the number of defective NAND blocks.

WRITE (10) SAME (41h) COMMAND

The WRITE (10) SAME (41h) command will request that the device server transfer a single logical block from the data-out buffer and write the contents of that logical block, with LBDATA and PBDATA bit modifications, to the specified range of logical block addresses.

Table 36. Write (10) Same (41h) Command

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (41h)							
1	WRPROTECT			Reserved		PBDATA	LBDATA	Obsolete
2	(MSB)			Logical Block Address				
3								(LSB)
5	Reserved			Group Number				
6	(MSB)			Number of Blocks				
8								(LSB)
9	Control							

Notes:

1 The WRPROTECT, PBDATA, LBDATA and Group Number fields are not supported. The command is rejected if any of these bits are set.

2 The Number of Blocks field must be non-zero unless the Logical Block Address is also set to zero. If the Number of Blocks and the Logical Block Address fields are both zero, then the 512 bytes of data supplied with the command are written to every user block on the device.

LOG SELECT COMMAND (4Ch)

See the *SMART Specification* section in this manual for details on the LOG SELECT pages that are supported.

LOG SENSE COMMAND (4Dh)

The LOG SENSE command provides a method for the application client to retrieve statistical or other operational information maintained by the SCSI target device about the SCSI target device or its logical units. The command is complementary to the LOG SELECT command. The only LOG SENSE page code supported is 0x00. The PPC and SP bits (Bits 1 and 0 of CDB Byte 1) must be zero and the PC bits must select the cumulative values (CDB Byte 1 must be set to 0x40). Bytes 1, and 5 through 8, are not supported. The Drive will return a CHECK condition if non-zero. Byte 2 must be 0x40, as only cumulative values are supported. See the *SMART Specification* section in this manual for details on the LOG SENSE pages that are supported.

Table 37. *Log Sense Command*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (4Dh)							
1	Reserved						PPC	SP
2	PC		Page Code					
3	Reserved							
4								
5	(MSB)	Parameter Pointer						
6								(LSB)
7	(MSB)	Allocation Length						
8								(LSB)
	Control							

MODE (10) SELECT (55h) COMMAND

This command is similar to the Mode (6) Select (15h) command. It is used to modify the device information contained in mode pages of the target device.

Table 38. Mode (10) Select (55h) CDB

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (55h)							
1	LUN			PF	Reserved			SP
2	Reserved							
3	Reserved							
5	Reserved							
6	Reserved							
8	Parameter List Length							
9	Control							

The following MODE PAGES are supported:

Page	Description
0x00	Vendor-Specific. Please see the SMART Specification section in this manual.
0x01	Read/Write error recovery. All bits can be changed but only the PER bit is processed.
0x02	Disconnect/Reconnect. On the maximum burst size field (Bytes 10 and 11) can be changed.
0x07	Verify error recovery. All bits can be changed but only the PER bit is processed.
0x19	Fibre Channel Port Control. All bits can be changed but only the DTFD, DLM, RHA, ALWI and DTOL1 bits are processed.
0x1C	Informational Exceptions Control. Please see the SMART Specification section in this manual.

MODE SENSE (10) COMMAND (5Ah)

The MODE SENSE (10) command provides a means for a target to report parameters to the initiator. It is complementary to the MODE SELECT (10) command. Byte 9 is ignored.

Table 39. *Mode Sense (10) Command (5Ah)*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (5Ah)							
1	0	0	0	Reserved	DBD	Reserved		
	Reserved							
2	PCF		Page Code					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7	(MSB)	Allocation Length						
8								(LSB)
9	Control							

A Disable Block Descriptors (DBD) bit of zero indicates that the target may return zero or more block descriptors in the returned MODE SENSE data, at the target's discretion. A DBD bit of one specifies that the target shall not return any block descriptors in the returned MODE SENSE data. The page control (PC) field defines the type of mode parameter values to be returned in the mode pages. The page code specifies which mode page to return.

Table 40. *Page Code Field Descriptions for Mode Sense (10)*

Page Code	Description	Subclause
00h	Vendor-specific (does not require page format)	
01h - 1Fh	See specific device types	
20h - 3Eh	Vendor-specific (page format required)	
3Fh	Return all mode pages	

PERSISTENT RESERVE IN (5Eh) COMMAND

The PERSISTENT RESERVE IN (5Eh) command will obtain information about persistent reservations and reservation keys that are active within the device server. The command is complementary to the PERSISTENT RESERVE OUT (5Fh) command. Byte 9 is ignored for both commands.

Table 41. Persistent Reserve In

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (5Eh)							
1	Reserved			Service Action				
2	Reserved							
6								
7	(MSB)	Allocation Length						
8								(LSB)
9	Control							

PERSISTENT RESERVE OUT (5Fh) COMMAND

Table 42. Persistent Reserve Out

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code (5Fh)							
1	Reserved			Service Action				
2	Reserved							
6								
7	(MSB)	Parameter List Length						
8								(LSB)
9	Control							

READ (12) DEFECT DATA (B7h)

This command functions the same as READ (10) DEFECT DATA (37h). The defect data cannot be associated with a specific host block and corresponding cylinder/head information. *See READ (10) DEFECT DATA (37)* for more information.

UNSUPPORTED COMMANDS

Table 43 lists the mandatory commands that are not supported by the drive.

Table 43. *Unsupported Mandatory Commands*

Command	Command Code	Description
Request Sense	03h	Device returns sense data with every failed command as part of response information.

SMART SPECIFICATION

OVERVIEW

This section provides the details of the implementation of SMART features for the SSD. SMART is an acronym Self-Monitoring, Analysis and Reporting Technology. SMART originally began as a specification for ATA devices. The specification has been adapted so that SCSI devices can support some of the SMART capabilities. As this specification was originally conceived for drives based on spinning platter technology, not all of the reporting features are relative to flash-based media drives. For example, spinning disks may hold counters for the number of seek errors that occur, or report to the host when the seek error counter reaches a threshold. Obviously, these features are not relevant for a drive with flash-based media.

EVENTS

SMART allows the drive to track internal events and report problems to the host in an effort to predict an impending failure. A drive with flash media and a SCSI host interface hold values and thresholds. Although each of the following events has user-selectable thresholds, the drive will impose minimum and maximum values to guard against improper use:

- Spare Sector Availability
- Read Error Correction Bits and Count
- Write Error Rate
- Erase Error Rate
- Read Error Rate
- Temperature

SPARE SECTOR AVAILABILITY

As the flash wears out, blocks that cannot be reliably erased or written are added to a grown defect list. As this list grows, the number of spare blocks will decrease. During normal operation, the firmware will attempt to free blocks by locating blocks that are invalid, spare, or consolidating blocks. Normally this will increase the number of free blocks. The threshold for triggering the process of locating more free blocks is set in the firmware. A user-selectable threshold can be specified as a percentage of free blocks. When the grown defect list grows to the point where this threshold cannot be reached, the spare sector availability reporting methods will be invoked.

Read Error Correction Bits and Count

When blocks are read from the flash, the ECC engine will report which commands were completed with the aid of ECC correction. The drive will maintain a running count. When this count changes, a percentage is calculated to provide a rate at which these errors are being generated. The rate is related to the number of flash Read commands that were issued. The drive also maintains a threshold value and uses it to report events to the host. To avoid reporting issues with bursts of errors, the counts will be maintained to reflect what event(s) occurred during the last five (5) minutes of operation.

Write, Erase and Read Error Rate

The drive will maintain a simple count of when the Write, Erase and Read commands fail. It also maintains a percentage or rate of failure in relation to the flash Write, Erase or Read commands issued and compares it against threshold values when the value increases. To avoid reporting issues with bursts of errors, the counts are maintained to reflect what events occurred during the last five (5) minutes of operation.

Temperature

The drives are able to read and check the temperature against a threshold. Drives report the temperature as defined by the SCSI specification.

Event Testing

The host software can select a TEST mode to check the reporting methods. When this mode is set, the drive will generate TEST notifications using the selected reporting methods.

Diagnostics

While not directly related, there are some SMART request and reporting features for drive diagnostics. These reporting features involve the host requesting that the drive perform either a short or extended diagnostic. Typically, these are initiated as background tasks that perform media checks. These media checks verify small or large media areas. The drive is required to hold the information for the last twenty (20) test, including the completion status. The recorded information is then made available to the host.

Note: This feature is not supported.

SCSI Implementation

For SCSI, Fibre Channel and SAS connections, there are two topics related to SMART. The first is implemented using the LOG SENSE and LOG SELECT commands and associated pages. While the specification for these commands permit the configuration and reporting of threshold parameters, these features are not supported and are used only to obtain the current counts or readings. As an alternative, the MODE SENSE and MODE SELECT commands and associated pages specifically address threshold settings and reporting methods.

EVENTS CURRENT VALUES

The LOG SENSE and LOG SELECT commands will report the previously detailed events. The LOG SENSE command will only report the current values. As current values are only supported by the LOG SELECT command is only available to reset the values as described in the following sections. Commands issued with values that are not supported or are invalid are terminated with a CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN CDB. Commands that supply parameter pages that are unsupported or contain unsupported fields will be terminated with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER TEST.

The log pages that are supported by these commands are constructed from small log parameter tables which each have the same defined style. The following is an example of a log parameter table.

Table 44. *Log Parameter Table Example*

	Bit							
Byte	7	6	5	4	3	2	1	0
0	(MSB)	Parameter Code						
1								(LSB)
2	DU	DS	TSD	ETC	TMC		Format & Linking	
3	Parameter Length (n - 3)							
4	Parameter Value							
n								

The parameters of the table are as follows:

Name	Description	
DU	Disable Update Bit	If set to 0, the device shall update this parameter according to the user-specific levels. If set to 1, the device shall not update this parameter.
DS	Disable Save	If set to 1, the saving of the parameter is disabled. A value of 0 indicates that the value may be saved.
TSD	Target Save Disable	If set to 0, the parameter is saved by the device at vendor-specific intervals. If set to 1, implicit saving is disabled.
ETC	Enable Threshold Comparison	If set to 1, a comparison between the current and threshold value is made whenever the parameter is updated. Set to 0 if no comparison is made.
TMC	Threshold Meet Criteria	Defines the basis for which comparisons are made.
Format & Linking		Specifies how the parameter value is represented.

LOG SENSE

Byte	Bit 7	6	5	4	3	2	1	0
0	Operation Code = 4Dh							
1	Reserved						PPC	SP
2	PC		Page Code					
3	Sub Page Code							
4	Reserved							
5	(MSB)		Parameter Pointer					
6								(LSB)
7	(MSB)		Allocation Length					
8								(LSB)
9	Control							

The parameters of the table are as follows:

Name	Description	
PPC	Parameter Pointer Control	If set to 1, the device shall return parameters that have changed since the last LOG SENSE/LOG SELECT command. The device shall only return parameter codes which have a value greater than or equal to the number specified in the parameter pointer field. If set to 0, the device will return all parameter codes greater than or equal to the parameter pointer field. *The PPC bit and the Parameter Pointer fields are not currently supported by the SSD*.
SP	Save Pages	If set to 1, the device shall save the parameter values that were requested to non-volatile memory, where the DS bit of the parameter block is set to 1. *The saving of parameters is optional and not supported by the SSD*.
PC	Page Control	This parameter controls what type of page values the command is processing. *Only current cumulative values are supported by the SSD*.
Page Code Sub Page Code		The Page Code and Sub Page Code fields contain the page and subpage to which the other command bytes apply. A page code and subpage code of 0 specify that the command bytes apply to all pages and subpages. A value of FFh in the Sub Pages field denotes the command bytes apply to all subpages of the specified page; otherwise, specific pages and subpages must be specified.
Allocation Length		The Allocation Length field requests the maximum number of bytes to transfer.
Control		*The Control field is present for all SCSI commands. It is not relevant and is not supported by any SSD command.*

LOG SELECT

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Operation Code = 4Ch							
1	Reserved						PCR	SP
2	PC		Page Code					
3	Sub Page Code							
4	Reserved							
5	Reserved							
6								
7	(MSB)		Parameter List Length					
8								(LSB)
9	Control							

The parameters of the table are as follows:

Name	Description	
PCR	Parameter Code Reset	Set to 1 to request that the parameters are reset.
SP	Save Pages	If set to 1, specifies that the device shall save the parameter values requested to non-volatile memory, where the DS bit of the parameter block is set to 1. *The saving of parameters is optional and not supported by the SSD*.
PC	Page Control	This parameter controls what type of page values the command is processing. *Only current cumulative values are supported by the SSD*.
Page Code Sub Page Code		The Page Code and Sub Page Code fields contain the page and subpage to which the other command bytes apply. A page code and subpage code of 0 specify that the command bytes apply to all pages and subpages. A value of FFh in the Sub Pages field denotes the command bytes apply to all subpages of the specified page; otherwise, specific pages and subpages must be specified.
Parameter List Length		The Parameter List Length specifies the length, in bytes, of the parameter buffer to be received by the device.
Control		*The Control field is present for all SCSI commands. It is not relevant and is not supported by any SSD command.*

As none of the log parameters are changeable, the only LOG SELECT command that is supported is the one that is used to reset the current cumulative counts for a specified page. In this case, PCR = 1, SP = 0, PC = 01b. The page and subpage code specify the page and subpage to reset. There are no parameters for this command, so Parameter List Length is 0. Control should also be set to 0.

SUPPORTED LOG PAGES

As previously mentioned, only the current cumulative values for these pages are made available, and none of the pages can be changed using the LOG SELECT command other than to reset counter fields.

LOG PAGE 0H - SUPPORTED LOG PAGES AND SUB PAGES

Page 0 indicates the supported Log Sense pages. This page is used to determine which additional pages an initiator can request. None of the supported pages have subpages.

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Reserved		Page Code = 00h					
1	Reserved							
2	Page Length = 0006h							
3	(Number of Supported Pages)							
4	First Supported Page 00h (Supported Pages)							
5	Second Supported Page 02h (Write Errors)							
6	Third Supported Page 03h (Read Errors)							
7	Fourth Supported Page 2Fh (SMART Sense & Temperature)							
8	Fifth Supported Page 30h (Vendor Unique - Erase Errors)							
9	Reserved							

LOG PAGE 2H - WRITE ERRORS

This page enables the host to extract the number of flash WRITE commands that have failed to complete successfully. A percentage is derived using Write Errors/Write Commands to create a baseline for a threshold comparison. This information is provide since Power On or Last Parameter Reset.

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Reserved		Page Code = 02h					
1	Reserved							
2 - 3	Page Length = 0060h							
4 - 5	Parameter Code = 0000h (Errors Corrected without Delays)							
6	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
7	Parameter Length = 08h							
8 - 15	Errors Corrected without Delays							
16 - 17	Parameter Code = 0001h (Errors Corrected with Possible Delays)							
18	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
19	Parameter Length = 08h							
20 - 27	Errors Corrected with Possible Delays							
28 - 29	Parameter Code = 0002h (Total Re-Writes)							
30	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
31	Parameter Length = 08h							
32 - 39	Total Re-Writes							
40 - 41	Parameter Code = 0003h (Total Errors Corrected)							
42	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
43	Parameter Length = 08h							
44 - 51	Total Errors Corrected							
52 - 53	Parameter Code = 0004h (Total Times Correction Algorithm Processed)							
54	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
55	Parameter Length = 08h							
56 - 63	Total Times Correction Algorithm Processed							
64 - 65	Parameter Code = 0005h (Total Bytes Processed)							
66	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
67	Parameter Length = 08h							
68 - 75	Total Bytes Processed							

76 - 77	Parameter Code = 0006h (Total Uncorrected Errors)						
78	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
79	Parameter Length = 08h						
80 - 87	Total Uncorrected Errors						
88 - 89	Parameter Code = 8000h (Vendor Unique - Flash Write Commands)						
90	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
91	Parameter Length = 08h						
92 - 99	Flash Write Commands						

LOG PAGE 3H - READ ERRORS

This page enables the host to extract the number of flash READ commands which have failed to complete successfully. Should a READ command fail, the only course of action is to retry the READ. Errors corrected without delay are READ errors which have completed the ECC correction. This information is provided since the Power On or Last Parameter Reset.

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Reserved		Page Code = 03h					
1	Reserved							
2 - 3	Page Length = 0060h							
4 - 5	Parameter Code = 0000h (Errors Corrected without Delays)							
6	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
7	Parameter Length = 08h							
8 - 15	Errors Corrected without Delays							
16 - 17	Parameter Code = 0001h (Errors Corrected with Possible Delays)							
18	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
19	Parameter Length = 08h							
20 - 27	Errors Corrected with Possible Delays							
28 - 29	Parameter Code = 0002h (Total Re-Reads)							
30	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
31	Parameter Length = 08h							
32 - 39	Total Re-Reads							
40 - 41	Parameter Code = 0003h (Total Errors Corrected)							
42	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
43	Parameter Length = 08h							
44 - 51	Total Errors Corrected							

52 - 53	Parameter Code = 0004h (Total Times Correction Algorithm Processed)						
54	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
55	Parameter Length = 08h						
56 - 63	Total Times Correction Algorithm Processed						
64 - 65	Parameter Code = 0005h (Total Bytes Processed)						
66	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
67	Parameter Length = 08h						
68 - 75	Total Bytes Processed						
76 - 77	Parameter Code = 0006h (Total Uncorrected Errors)						
78	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
79	Parameter Length = 08h						
80 - 87	Total Uncorrected Errors						
88 - 89	Parameter Code = 8000h (Vendor Unique - Flash Read Commands)						
90	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
91	Parameter Length = 08h						
92 - 99	Flash Read Commands						

LOG PAGE 2FH - INFORMATIONAL EXCEPTIONS LOG PAGE

This page is the only log page which contains SMART information. It can also be used to check the temperature readings for devices equipped with temperature sensors. Any outstanding SMART Sense information is submitted with this page.

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Reserved		Page Code = 2Fh					
1	Reserved							
2 - 3	Page Length = 0008h							
4 - 5	Parameter Code = 0000h							
6	DU = 0	DS = 0	TSD = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
7	Parameter Length = 04h							
8	SMART Sense Code Byte							
9	SMART Sense Qualifier							
10	Most Recent Temperature Reading							
11	Vendor HDA Temperature Trip Point							

LOG PAGE 30H - VENDOR UNIQUE - ERASE ERRORS

This page allows the host to extract the number of flash ERASE commands that have failed to complete successfully. A percentage is calculated using ERASE Errors/ERASE Commands to form the basis for a threshold comparison. The Total Bytes Processed field is calculated by multiplying the Block Size and the Number of Commands. Non-savable parameters are provided since Power On or Last Parameter Reset. Saved parameters are totals.

	Bit							
Byte	7	6	5	4	3	2	1	0
0	Reserved		Page Code = 30h					
1	Reserved							
2 - 3	Page Length = 0060h							
4 - 5	Parameter Code = 0000h (Errors Corrected without Delays)							
6	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
7	Parameter Length = 08h							
8 - 15	Errors Corrected without Delays							
16 - 17	Parameter Code = 0001h (Errors Corrected with Possible Delays)							
18	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
19	Parameter Length = 08h							
20 - 27	Errors Corrected with Possible Delays							
28 - 29	Parameter Code = 0002h (Total Re-Erase)							
30	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
31	Parameter Length = 08h							
32 - 39	Total Re-Erase							
40 - 41	Parameter Code = 0003h (Total Errors Corrected)							
42	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
43	Parameter Length = 08h							
44 - 51	Total Errors Corrected							
52 - 53	Parameter Code = 0004h (Total Times Correction Algorithm Processed)							
54	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
55	Parameter Length = 08h							
56 - 63	Total Times Correction Algorithm Processed							
64 - 65	Parameter Code = 0005h (Total Bytes Processed)							
66	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0		LBIN = 1	LP = 1
67	Parameter Length = 08h							

68 - 75	Total Bytes Processed						
76 - 77	Parameter Code = 0006h (Total Uncorrected Errors)						
78	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
79	Parameter Length = 08h						
80 - 87	Total Uncorrected Errors						
88 - 89	Parameter Code = 8000h (Vendor Unique - Flash Erase Commands)						
90	DU = 0	DS = 1	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
91	Parameter Length = 08h						
92 - 99	Flash Erase Commands						
100-101	Parameter Code = 8001h (Vendor Unique - Manufacturers Defect Count)						
102	DU = 0	DS = 0	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
103	Parameter Length = 08h						
104-111	Manufacturers Defect Count						
112-113	Parameter Code = 8001h (Vendor Unique - Grown Defect Count)						
114	DU = 0	DS = 0	TDS = 0	ETC = 0	TMC = 0	LBIN = 1	LP = 1
115	Parameter Length = 08h						
116-123	Grown Defect Count						

SMART Event Notification via SCSI

The notification and monitoring of SMART events under SCSI systems is controlled using the MODE SENSE and MODE SELECT commands and pages. The MODE SENSE and MODE SELECT pages that affect SMART are page 1Ch, the Informational Exceptions control mode page, and page 00h, a Vendor-Unique page that permits the changing of event thresholds. SMART event notification is achieved under SCSI via command status bytes and sense information. Page 1Ch permits the host to select what events are enabled for notification and how those events are notified. Both of these pages can be requested to return current, default, changing and saved values.

The saving of values to a non-volatile area is optional within the SCSI specification. However, the SSD does not currently support the saving of these pages to a non-volatile area. The saved values are the current values.

MODE PAGE 00H - VENDOR UNIQUE THRESHOLD VALUES

	Bit							
Byte	7	6	5	4	3	2	1	0
0	PS = 0	SFP = 0	Page Code = 00h					
1	Page Length = 6							
2	Low Free Pages Threshold							
3	Write Error Rate Threshold							
4	Read Error Rate Threshold							
5	Erase Error Rate Threshold							
6	Temperature Threshold °C							
7	ECC Correction Threshold							

Since the pages cannot be saved, the PS (Parameters Saveable) bit will be 0 for MODE SENSE. This bit is reserved for the MODE SELECT command.

SFP (Subpage Format) will be set to 0 to indicate that this is a page_0 mode page format.

The Low Free Pages Threshold is based on the percentage of free blocks. This figure is calculated on a per channel level. If this limit is reached on any channel, it may trigger an informational exception report.

Write, Read, and Erase error thresholds are represented as a percentage of how many commands have failed with regard to the total number of commands. For example, the Write threshold will be compared to the total number of Write Errors divided by the total number of Write commands, multiplied by 100. The Erase failure rate will also be calculated according to the total erase failures. The Read error rate will be compared using the same method, but only the total Read failures will be used, and not Reads that have completed albeit with ECC correction applied. These fields are checked at 5 minute intervals using the data for the last 5 minutes.

ECC Correction Thresholds are expressed as a percentage with regard to the total number of Read commands. For example, the ECC Correction Threshold is compared against the number of ECC corrections divided by the total number of Read commands, multiplied by 100. This field is checked on a 5 minute interval using data for the last 5 minutes. The temperature is also checked on a 5 minute level.

MODE PAGE 1CH - INFORMATIONAL EXCEPTIONS CONTROL MODE PAGE

	Bit							
Byte	7	6	5	4	3	2	1	0
0	PS = 0	SFP = 0	Page Code = 1Ch					
1	Page Length = 0Ah							
2	PERF	Reserved	EBF	EWasc	DExcept	TEST	EBackErr	LogErr
3	Reserved				MRIE			
4	(MSB)	Interval Timer						
7								(LSB)
8	(MSB)	Report Count						
11								(LSB)

The parameters of the table are as follows:

Name	Description	
PS	Parameters Saveable	Pages cannot be saved, so the PS bit will be 0 for MODE SENSE. This bit is reserved for the MODE SELECT command.
SFP	Subpage Format	Is set to 0 to indicate that this is a page_0 mode page format. This bit is not permitted to change.
PERF	Performance Bit	Is set to 0 to indicate that the informational exception operations may impact performance. This bit is not permitted to change.
EBF	Enable Background Functions	Is set to 0 to indicate that the background functions are disabled. This bit is not permitted to change.
EWasc	Enable Warning Bit	If set to 0, the device shall disable the reporting of warnings. If set to 1, the device shall report warnings as specified by the MRIE field.
DExcept	Disable Exception Control	Is set to 0, indicates that threshold exceeded is reported. The reporting method shall be specified by the MRIE field.
TEST	TEST	The TEST bit set to 1 shall create a test failure at the next time interval, as specified by the Interval Timer, if the DExcept bit is set to 0. The TEST failure condition will reported as FAILURE PREDICTION THRESHOLD (FALSE). A MODE SELECT command that attempts to set both the TEST bit and DExcept to 1 will be terminated with CHECK CONDITION status, with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST. A TEST bit set to 0 will indicate that the device shall not generate test device failure notifications. LogErr shall be set to 0 to indicate that the logging of informational exceptions is vendor specific. This field is not permitted to change.
EBackErr	EBackErr	This bit shall be set to 0 to indicate that the reporting of background scan errors is disabled. This bit is not permitted to change.

MRIE	MRIE	The Method of Reporting Informational Exceptions (MRIE) field defines the method that shall be used by the device to report informational exceptions. The priority of reporting multiple informational exceptions is vendor specific.
Interval Timer	Field	This field will specify the time, in 100 millisecond increments, that the device server shall use for reporting that an informational exception condition has occurred. The device shall not report informational conditions that exceed the frequency specified in this field.
Report Count	Field	This field will specify the maximum number of times that an informational exception will be reported. A value of 0 indicates that there is no limit on the number of times the informational exception is reported.

Temperature high conditions will be reported as warnings when EWasc is set to 1 and a temperature sensor is present. All other monitoring counts will be reported when the DExcept is set to 0. *The MRIE field will specify the method of reporting as shown in Table 45*. Reporting will be via SCSI status and the appropriate sense information when an informational exception report is pending. As this MODE SENSE/MODE SELECT page cannot be saved it is reset at Power On or on reception of LOGICAL UNIT RESET. In addition, if this page is changed, a UNIT ATTENTION condition is reported to all other initiators with the additional sense code set to MODE PARAMETERES CHANGED.

Table 45. MRIE Reporting Method Codes

Code	Description
0h	No reporting of Informational Exception Conditions.
1h	Asynchronous event reporting (obsolete). *Not supported by the SSD*.
2h	*Generate Unit Attention*. The command will be terminated without being processed and a CHECK CONDITION with a sense key set to UNIT ATTENTION will be returned. Additional sense information will represent the informational exception being reported.
3h	*Conditionally Generate Recovered Error*. The device shall return a check condition for any command which has completed with good status. The sense key shall be set to RECOVERED ERROR and the sense code and qualifier shall indicate the cause of the informational exception. If the TEST bit is set to 1 by this command the status shall be returned on the next command received that is normally capable of returning an informational exception, when the TEST bit is set to 0. In some standards this is controlled by the post error (PER) bit in the Read-Write Error Recovery mode page. *The SSD does not support this page and therefore does not support this MRIE*.
4h	*Unconditionally Generate Recovered Error*. The device shall return a check condition for any command which has completed with good status. The sense key shall be set to RECOVERED ERROR and the sense code and qualifier shall indicate the cause of the informational exception. If the TEST bit is set to 1 by this command the status shall be returned on the next command received that is normally capable of returning an informational exception, when the TEST bit is set to 0.

5h	*Generate NO SENSE*. The device shall return a check condition for any command which has completed with good status. The sense key shall be set to NO SENSE and the sense code and qualifier shall indicate the cause of the informational exception. If the TEST bit is set to 1 by this command the status shall be returned on the next command received that is normally capable of returning an informational exception, when the TEST bit is set to 0.
6h	*Only Report Informational Exception Condition on Request*. The device shall preserve informational exception information and make it available to initiators via the REQUEST SENSE command. The sense key shall be set to NO SENSE and the sense code shall indicate the cause of the informational exception.
	Note: *The SSD does not preserve sense information as it currently has a Fibre Channel interface and any sense information is subsequently sent with the command completion response. For this reason it does not support the REQUEST SENSE command or this MRIE.*
7h - Bh	Reserved
Ch - Fh	Vendor Specific

The sense code and qualifier for the monitored events within the SSD are reported with the sense information listed in *Table 46*.

Table 46. Events, Sense Codes and Qualifiers

Monitored Event	Sense Code	Qualifier
Spare Sector Availability	5Dh	14h
Read Error Correction Bits (Vendor-Unique)	80h	33h
Write Error Rate	5Dh	4Ah
Erase Error Rate (Vendor-Unique)	80h	4Bh
Read Error Rate	5Dh	32h
Temperature	0Bh	01h

FIBRE CHANNEL STANDARD

OVERVIEW

The Fibre Channel standard has coined various terms that are important to know when using the SSD. This section will present the basic terms in context to help provide an intuitive understanding of the Fibre Channel interface.

FIBRE CHANNEL ARBITRATED LOOP

The “Fibre” or “Link” refers to the copper or optical cable that connects two Fibre Channel devices via their ports. A device, known as a “node”, can have more than one port. For example, the SSD is a node with two ports that is linked with a copper cable, or fibre. Nodes are connected in a “topology”. The SSD may be connected to an “Arbitrated Loop” (AL), where the nodes of the loop are connected in a circle. *See Figure 4*.

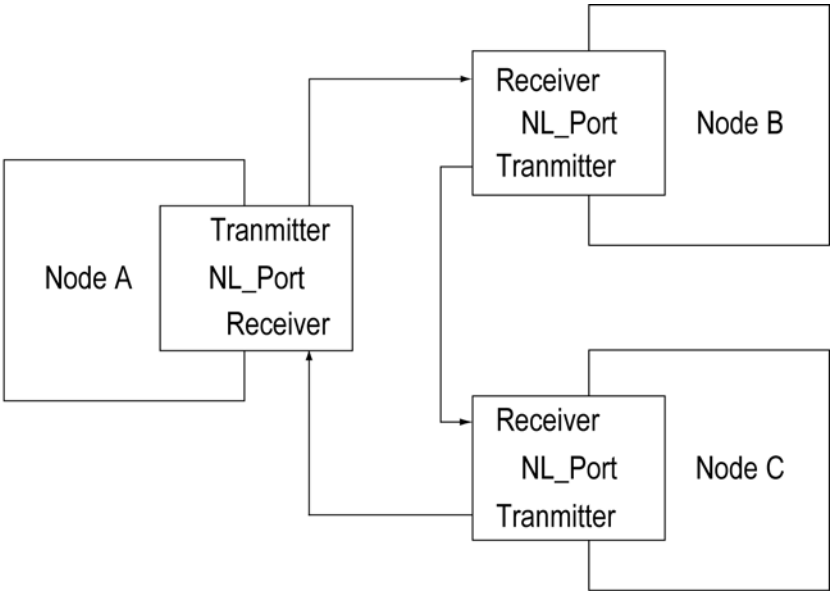


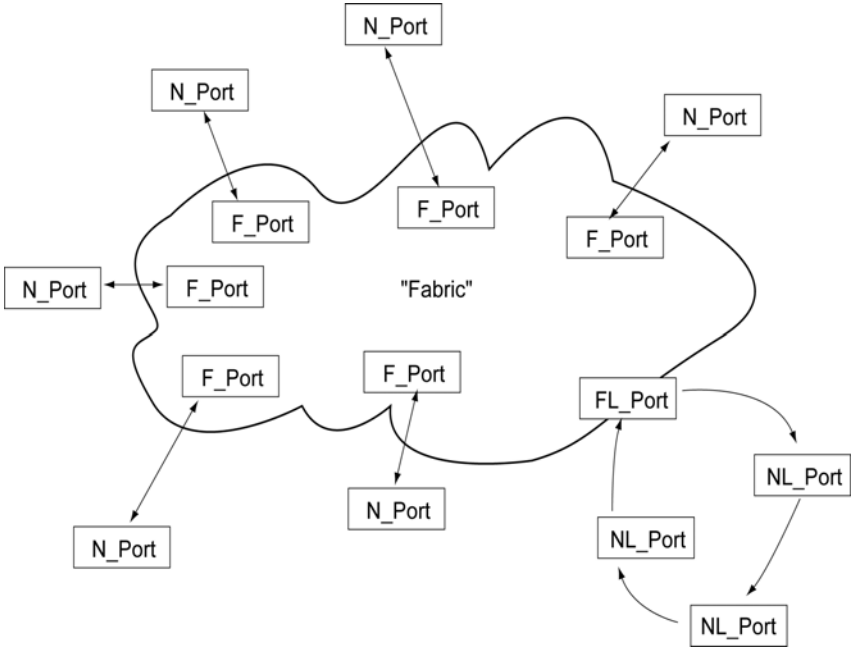
Figure 4. *Arbitrated Loop Topology Connection*

An Arbitrated Loop has certain rules:

1. Each port on the loop has an Arbitrated Loop Physical Address (AL-PA) that is set on the “backplane” or the board to where the device is connected. Once set, the port attached to the backplane inherits the AL-PA.
2. The AL-PA must have “neutral disparity”, i.e., the number of binary 0s and 1s in the AL-PA are equal when 10-bit encoded. Out of the 127 addresses, one is reserved on the loop for the fabric switch, leaving 126 possible AL-PAs.
3. There may be more than 126 ports physically attached to the on a loop, but only 126 will be functional, with the remaining unable to obtain valid addresses.
4. If the AL-PA of a device is not unique on the loop, the device will not participate on the loop. The user must choose another “hard address”, i.e., an AL-PA. If a unique hard address cannot be set, the user can set the backplane to an AL-PA so that the loop will assign a “soft address” to the device.
5. The lower the AL-PA, the higher priority the device has on the loop while keeping “fairness”. Fairness means that every device on the loop has a chance to own the loop once before another device owns it twice.

FABRIC NODE CONNECTION

The SSD can also be connected to a “fabric” where any node on the fabric can connect to any other node in the fabric. *See Figure 5*.



Port	Description
F_Port	Fabric Port
N_Port	Node Port
FL_Port	Fabric Arbitrated Loop Port
NL_Port	Node Arbitrated Loop Port

Figure 5. *Fabric Node Connection*

An Arbitrated Loop has the following states:

Monitoring	Each port acts as a repeater while listening for further instructions.
Arbitration	The port requests to own the loop.
Open	The port wins arbitration and connects to another device.
Closed	The port relinquishes control of the loop and the loop is in the process of returning to a monitoring state.

A node can be “hot plugged” where it is inserted or removed from the loop. When hot plugged, the loop loses “sync” and must “reinitialize”. The loop will be able to recover any lost communications during the hot plugging. Typically, a backplane may have a “bypass” circuit. *See Figure 6*. When enabled, the bypass circuit will remove the device from the loop while keeping the loop connected. The loop will remain operational while the device is connected, performs its POSTs, and becomes ready.

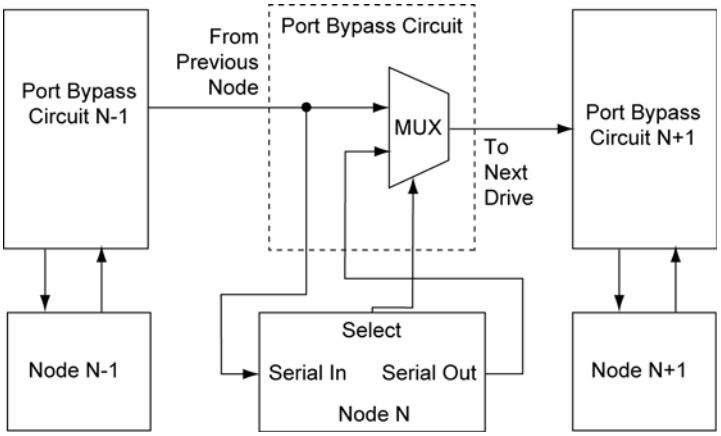


Figure 6. *Typical Backplane Bypass Circuit*

The Fibre Channel standard is structured into FCP Function Levels, where “FCP” is “Fibre Channel Protocol”. There is a hierarchy of function levels, written FC-0 to FC-4, and on top of those lies the Upper Level Protocols or ULP. *Table 47* summarizes each FCP level.

Table 47. *FCP Function Levels*

FCP Level	Description
FC-0	This level defines the cable, transceivers, and connector. For example, the SSD uses copper cable and a 40-Pin SCA-2 connector.
FC-1	This level defines the 8B/10B encoding of the basic word in the data stream. This encoding consists of four characters. A word contains data or contains an ordered set that serves as control information.
FC-2	This level defines how the words are structured in frames, sequences, exchanges and packets.
FC-3	This level defines the common services. All communication through a node passes through the common service protocol level, allowing networking features such as “stripping” data, and “multicasting” to many nodes.
FC-4	Maps the lower protocols to the ULPs.
ULP	This is the protocol that is transported by the Fibre Channel. For example, the SSD has FCP-SCSI as its ULP.

PHYSICAL CHARACTERISTICS

GENERAL PHYSICAL CHARACTERISTICS

MATERIALS

All acceptable enclosure materials have been independently tested by an NRTL and are certified to comply with the following standards:

- ANSI/UL60950-1-2002
- CAN/CSA-C22.2 No.60950-1-03

DRIVE ASSEMBLY WEIGHT

The weight of the SSD varies according to the specific set of design characteristics of the drive. The storage capacity, IC stacking technology (if used), case material (aluminum alloy or plastic) and flash controller/memory configuration all determine the exact weight of the drive:

STORAGE CAPACITIES

Table 48 lists the available unformatted capacities, total data bytes, and corresponding total logical data blocks in hexadecimal values for each model of the SSD.

Table 48. *Storage Capacities*

Unformatted Capacity	Total Data Bytes	Total Logical Data Blocks
18 GB	18,253,611,008	35,651,584 (2200000 Hex)
36 GB	36,507,222,016	71,303,168 (4400000 Hex)
73 GB	73,014,444,032	142,606,336 (8800000 Hex)
146 GB	146,028,888,064	285,212,672 (11000000 Hex)

EXTERIOR DIMENSIONS

The internal components are housed within a machined aluminum alloy enclosure. The overall dimensions for the 3.5-inch form factor are illustrated in *Figure 7*.

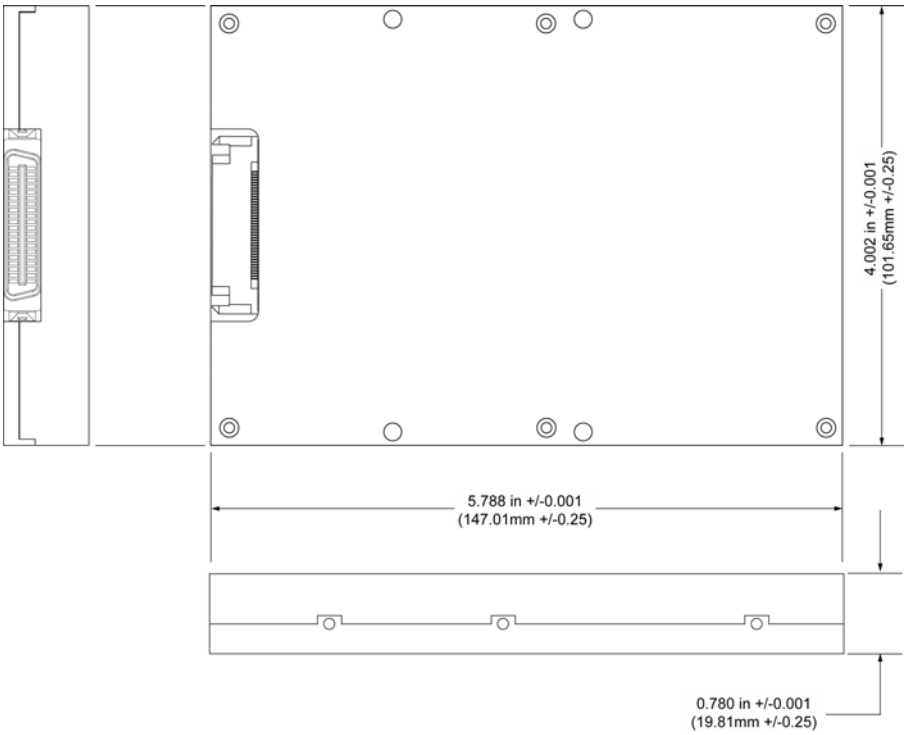


Figure 7. *Zeus^{IOPS} 3.5-Inch Dimensions*

ENVIRONMENTAL CHARACTERISTICS

OVERVIEW

The SSD is subjected to a series of environmental tests to validate the operation of the drive in harsh and mobile conditions. The SSD will operate without degradation within the ambient temperature, relative humidity and altitude ranges as specified in the following sections.

OPERATING TEMPERATURES

The SSD will operate without degradation within the ambient temperature ranges specified in *Table 49*. For the operating temperature, the ambient air temperature is that of the inlet air for the equipment.

Table 49. *Operating Temperatures*

	Centigrade (^{O}C)		Fahrenheit (^{O}F)	
Operating Temperature	Minimum	Maximum	Minimum	Maximum
Commercial	0	70	32	158
Industrial	N/A	N/A	N/A	N/A

STORAGE TEMPERATURES

Note: Non-operating conditions include shipment and storage environments. *See Table 50*.

Table 50. *Storage Temperatures*

Storage Requirement	Criteria
Temperature Range	-40^{O}C to 85^{O}C
Maximum Temperature Gradient	30^{O}C/h
Short Duration Temperature	82^{O}C for 2h

MAXIMUM COMPONENT TEMPERATURES

Critical drive component temperatures must be kept within certain limits to prevent damage to the SSD. The approximate component locations within the drive are illustrated in *Figure 8*. *Table 51* lists the maximum component temperatures. Component U62 is the temperature sensor. Forced air cooling will be required in most applications to ensure optimal conditions.

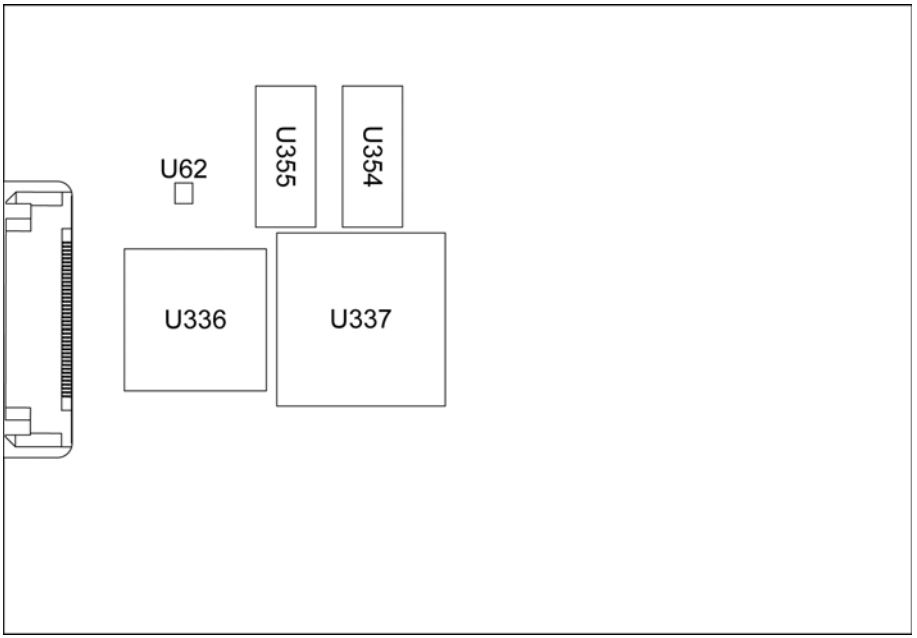


Figure 8. *Component Locations*

Table 51. *Maximum Component Temperatures*

Component	Designator	Maximum Temperature
Processor	U336	95°C
Flash Controller	U337	80°C

Relative Humidity

Table 52 lists the operating and storage relative humidity criteria for the SSD.

Table 52. *Relative Humidity Requirements*

Operating	Criteria
Relative Humidity Range (Non-Condensing)	8% to 90%
Maximum Wet Bulb Temperature	29°C
Maximum Relative Humidity Gradient	20%h
Storage (Non-Operating	Criteria
Relative Humidity Range (Non-Condensing)	8% to 90%
Maximum Wet Bulb Temperature	38°C
Maximum Relative Humidity Gradient	20%h

Altitude Parameters

Operating and non-operating (storage) altitude parameters for the SSD are the same. *See Table 53*. Altitude is referenced to sea level on a standard day at 19.8°C (58.64°F).

Table 53. *Operating and Non-Operating Altitudes*

Altitude Parameter	Meters	Feet
Low Altitude Limit	-304.80	-1,000
High Altitude Limit	24,384	80,000

Shock and Vibration

This section specifies the capacity of the SSD to withstand shock and vibration. Resonance may occur if the SSD is placed in an enclosure. It is the responsibility of the user to design the mounting such that the SSD movement is within the specified ranges despite resonance.

Failure Criteria

Test failures are defined as:

- Any single hard unrecoverable error.
- Damage that renders a product inoperable.
- Damage that adversely affects the performance specifications.

Operating Shock and Vibration

For random vibration, the SSD will perform without errors after being tested at 15 min/axis on three axes (X, Y and Z). During the operational vibration, the SSD will perform continuous reads. Operating shock and vibration levels are listed in *Table 54*. In addition to the aforementioned Failure Criteria, during the operating random vibration, the transfer rate of the SSD should not degrade by more than 10%.

Table 54. *Operating Shock and Vibration*

Parameter	Value	Condition
Operating Shock	1	G, half-sine, 2ms duration, 20Hz to 600Hz, 3 cycles per 3 axes.
Operating Vibration	60	G, RMS, random, 20Hz to 600Hz, 1 hour duration, 3 axes

Drop Testing

The SSD will withstand three (3) drops on a concrete floor from 1.524m (60 inches) on each of six (6) axes, +/-X, +/-Y, and +/-Z, without any damage when packaged.

INSTALLATION

SYSTEM REQUIREMENTS

There is a risk of electrocution! Use extreme caution when handling the solid state drive and while connecting it to a power source. Observe all applicable electrical safety rules while installing the solid state drive. Make sure to read and thoroughly understand this section before attempting to install the drive.

SCSI CONNECTIONS

The SSD can be installed in an operating system environment that supports SCSI-3 or greater devices (the SSD is intended to be compliant to future SCSI-4 standards). If the system does not have a Fibre Channel AL-Port, the user will need to supply and install an adapter before proceeding with the installation. If the system fails to recognize the drive, make sure the most recent drivers for the host adapter are installed. If the drive is connected to the motherboard, the drivers are provided by the motherboard manufacturer. Changes to the operating system are not required.

Make sure the following is on hand before installing the SSD:

- Phillips screwdriver
- Six 6-32 machine screws
- A cable suitable to connect the backplane or tailgate card to the HBA
- An available tailgate card or backplane connection.
- Available 12V power source

SINGLE CHANNEL OPERATION

The SSD is dual-ported and can be accessed simultaneously down both ports or channels. This allows the drive to be used on systems that have multi-pathing software, also known as “Dynamic Multi-Pathing” or DMP. The DMP software allows for two completely separate paths from the one host machine to access the same drive; the two separate paths are recognized as being logically connected together. This allows for some redundancy to be incorporated into the system. Systems that support DMP typically send commands to the drive down both channels, using the channel that is the least busy. If one channel fails for any reason then all commands are automatically switched to use the remaining active channel.

For host systems that are not DMP capable, having two paths from the same host machine to the same drive can cause problems. For example, if the two channels are connected to the same host machine when running an operating system that does not support DMP, two separate disks will be reported by the operating system even though both reported disks are the same physical storage. This can cause corruption to occur if the drive is subsequently accessed down both channels. *See Single Channel Mode for Early Revision Drives.*

DRIVE CONFIGURATION

To accommodate both DMP and non-DMP capable systems, the SSD can be configured so that it only operates (and is only visible) down one of the two channels. This feature is most likely to be used on systems that do not support DMP but where the drives in the same JBOD chassis are to be mirrored. Enabling just the A channel for the main drive and the B channel on the mirror drive will cause both drives to be visible via separate host channels, thereby preventing any single point of failure.

The feature is enabled by inserting a 2mm option jumper onto the two pins marked as JP1 on the underside of the drive. Please note that jumper JP1 is located on the 10-way right-angled connector that also serves as a test connector during manufacture. The drive will require power cycling after JP1 is installed or removed. When this feature is enabled, the LSB of the SELECT_ID determines the port that the drive will use. If the SELECT_ID is even, then port A is used. If the SELECT_ID is odd, then port B is used.

WARNING: Only insert a jumper across the pins clearly labeled as JP1 on the PCB silk-screen. If JP1 is not marked, then please read the following for information regarding early revision drives.

FAULT SIGNALS

Under certain conditions, the SSD will drive the Fault LED Out (fault signal) on the SCA-2 interface. In most system configurations, this will normally be connected to an LED on the chassis that is visible to the user.

POWER-ON FAULT CONDITIONS

The fault codes listed in *Table 55* indicate that a fault has been detected during the power-on sequence. As a result, the unit is in a non-operational state and remedial action is required to replace the unit.

Power-on fault codes are indicated as a series of flashes. The fault light will illuminate for 0.25 seconds (250mS), then turn off for 0.25 seconds (250mS), followed by a 2 second off interval. The number of flashes between each 2 second off period is used to indicate the different fault conditions.

Table 55. *Power-On Fault Codes*

Flash Series	Condition
1 Flash	Memory strobe adjustment failure.
2 Flashes	Memory address failure.
3 Flashes	Memory data failure.
4 Flashes	ECC error encountered during memory test.
5 Flashes	ECC detection/correction circuit failure.

The fault code should be noted (along with the drive serial number if possible), and either the supplier of the SSD unit or technical support should be contacted.

OPERATIONAL FAULT CODES

The following codes indicate that a fault has been detected during drive operation. The drive will remain operational despite the fault. The drive should be replaced at the earliest possible opportunity.

Operational fault codes are indicated as a series of flashes. The fault light will illuminate for 1 second, then off for 1 second, followed by a 10 second off delay. The number of 1 second flashes between each 10 second delay period are used to indicate the different fault conditions: 5, 7 or 9 flashes.

Table 56. *Operational Fault Codes*

Code	Condition	Description
5 Flashes	Power Backup Device Faulty	The power backup circuit has failed. The power backup circuit supplies power to the drive for a short period in the event of a power failure. The backup power allows the firmware to ensure that any active writes are completed. It also allows information to be saved so that the drive becomes ready promptly (< 30 seconds) when power is restored. If this fault code is active and power is unexpectedly lost, the drive may require several minutes to come ready when the power is restored. If this occurs, only the data blocks that were most recently written by the host will be lost. If those same data blocks are read when power is restored, the prior contents (prior to the lost write) will be returned. *No data will be permanently lost*. When this fault code is active the drive will save all information and prepare for power loss if a SYNCHRONIZE CACHE (10) command (Opcode 0x35) is received via the host SCSI interface. Most operating systems (Windows, Solaris, Linux, etc.) will issue this command automatically when shut down by the user. This will alleviate the potential problems associated with this fault condition.
7 Flashes	NAND Flash Write Protect Error	A write protect error was returned when the unit attempted to write to the flash media. The most likely cause is a faulty connection or voltage converter. If this error occurs continuously then access from the host machine will be locked out.
9 Flashes	NAND Busy Error	The BUSY pin from a NAND flash chip was asserted for too long. The most likely cause is a faulty connection. If this error occurs continuously then access from the host machine will be locked out.

Single Channel Mode for Early Revision Drives

On early revisions of the drive, JP1 did not exist. These drives are identified by having a serial number of “50” or less and only have an 8-way right-angled manufacturing connector. For this revision of drive, the feature is enabled by setting bit 6 of the LOOP_ID to “1”. The LOOP_ID is set using the SELECT_ID pins on the SCA-2 connector within the chassis to which the SSD is connected. *See the SEL_ID Function*.

The SELECT_ID bits are normally configured by jumpers or a switch that allows the ID of the drive to be set using the backplane of the SCA-2 connector. *Table 57* lists the various configurations of the SELECT_ID function.

Table 57. *SELECT_ID Configurations*

Bit 6	Bits 5 -1	Bit 0	Configuration Result
0	XXXXX	X	Loop ID 0 - 63 Drive operates down both channels.
1	XXXXX	0	Loop ID 64 - 126 and even Drive operates down channel A only.
1	XXXXX	1	Loop ID 65 - 127 and odd Drive operates down channel B only.

DRIVE ORIENTATION

The SSD can be installed in any number of orientations within the enclosure. The drive will operate and meet all the requirements as outlined in this specification regardless of the mounting orientation. *See Figure 9*.

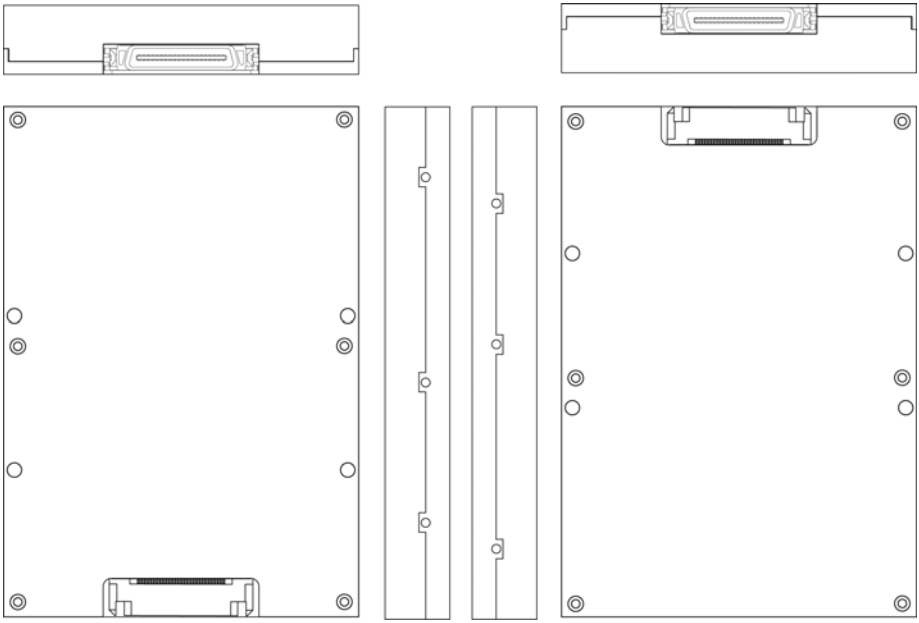


Figure 9. *Possible Drive Orientations*

PRIMARY HEAT GENERATION AREA

Figure 10 indicates the approximate location of the primary heat generation area on the underside of the SSD. See *Cooling Requirements*.

Exercise caution when handling the drive after extended operation. The heat generated by the internal circuitry can be substantial.

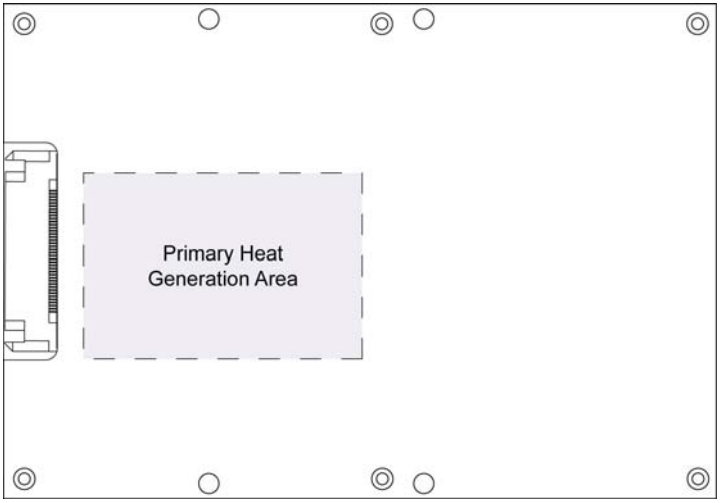


Figure 10. *Primary Heat Generation Area*

COOLING REQUIREMENTS

If necessary to maintain the required operating temperature range, the host enclosure may remove heat by conduction, convection, or other forced air flow. The suggested air flow patterns are shown in *Figure 11*.

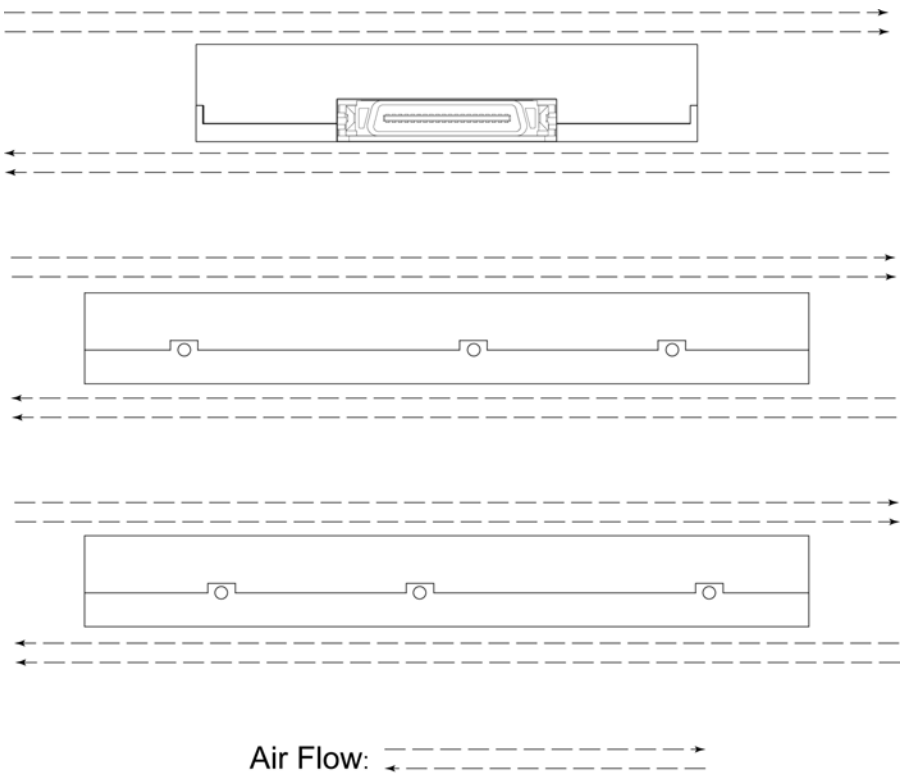


Figure 11. *Suggested Air Flow Patterns for Cooling*

MOUNTING DIMENSIONS

Figure 12 shows relative locations of the mounting holes. Careful attention should be made to the length of the mounting screws and the recommended torque to prevent damage to the enclosure; the maximum screw penetration is 5 mm. The mounting screw threads are 6-32 and the recommended torque is 0.5 Nm to 0.8 Nm.

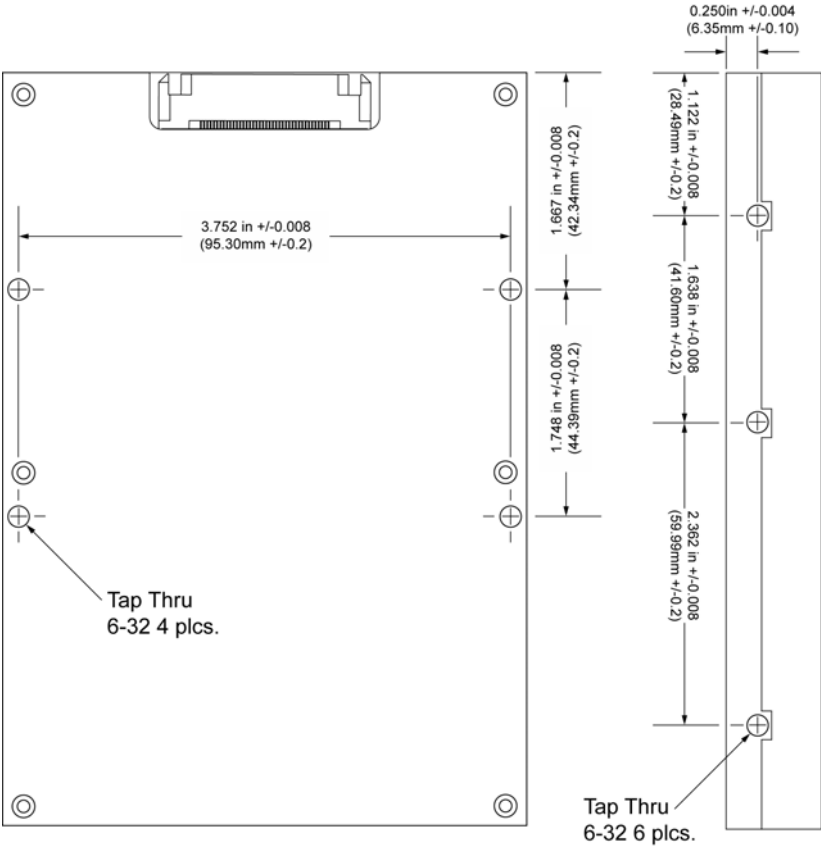


Figure 12. *Exterior Mounting Specifications*

Underside Mounting Holes	Side Mounting Holes
(4x) 6-32 Screws	(6x) 6-32 Screws
Maximum Depth: 5.0mm	Maximum Depth: 5.0mm
Maximum Torque: 0.8 Nm	Maximum Torque: 0.8 Nm

DRIVE INSTALLATION

Electrostatic Discharge or ESD can seriously damage the electronic components of the host system and solid state drive. It is very important to discharge any static electricity before you begin the installation procedure. You can touch an unpainted, grounded metallic surface to discharge any static charges that may be present on your body or clothing. As an alternative, you can also use an ESD protective wrist strap. You can minimize the possibility of damage due to ESD by avoiding physical contact with the electronic components.

To install the SDD in a server or host system:

1 Power down the computer/host system.

2 Remove the access cover.

3 Position the SSD in an available drive bay or choose a suitable mounting location.

4 Connect the SSD to the backplane or tailgate card. The connector on the drive is keyed to ensure that the signal and power connections to the drive are correctly oriented.

5 Secure the SSD within the drive bay or to the mounting surface using 6-32 machine screws. Apply sufficient torque to ensure that the drive is secure.

Note: Be aware of the depth of the mounting holes. *The maximum penetration depth of the drive's mounting holes is indicated in Figure 15*. The user may mount the drive using the side or underside mounting holes. Four (4) 6-32 screws will be required to mount the drive from the bottom; six (6) 6-32 screws to mount the drive using the side holes. It is recommended that the user secure the drive with at least four screws. To avoid damaging the drive, consider the thickness of the mounting surface when deciding on the screw length to use.

6 Replace the access cover and power on the computer/host system.

GROUNDING REQUIREMENTS

No special grounding circuitry is required. The signal and chassis grounds are not connected together in the drive. The user should provide maximum surface contact area when connecting the drive to the chassis ground to ensure minimal electromagnetic (EM) emissions.

Operating System Specifications

The SSD is compatible with Microsoft Windows® and alternative operating systems. The SSD is low-level formatted at the factory. However, the SSD must be partitioned and high-level formatted. The SSD can be formatted as boot drives or data storage drives using any standard disk partitioning and formatting utility.

Microsoft OS Compatibility

The SSD is fully compatible with the following Microsoft operating systems, using the native drivers supplied with the OS:

- Windows 2000, Service Packs 2, 3 and 4
- Windows 2000 Server, Advanced Server
- Windows XP Home and Windows XP Professional, Service Packs 1 and 2
- Windows XP, 64-Bit Extended
- Windows 2003 Standard, Enterprise, 64-bit, Web, Datacenter, Small Business Server
- Windows Vista
- MS-DOS
- Windows Pre-boot Environment (WinPE)

The drives are compatible with the current version of MS-DOS real-mode drivers bundled with any of the Microsoft operating systems for reading files from optical media.

Alternative Operating Systems

The drives are fully compatible with the following operating systems, using the native drivers supplied with the OS:

- Linux Distributions (with Fibre Channel support)
- Sun Microsystems Solaris 8 and 10
- SGI IRIX
- HPUX

System POST, Boot and Resume Times

The time required for the drive to become ready varies according to the capacity. The average time is 30 seconds. The total boot time will vary depending on the state of the capacitor-based power backup module. Under normal operation, the module will remain in a state where it holds enough of a charge to that the charging causes no delay to the boot-up. When the drive is new or remains without power for many hours, the capacitors on the power backup module will be discharged. If the capacitors are fully discharged the drive will take longer to start. For example: 18GB, fully discharged 35 seconds, charged 11 seconds; 146GB fully discharged 45 seconds, charged 23 seconds.

SSD Management Utility

The firmware and hardware on the SSD can be upgraded in the field. The drive management utility, “Giddy”, uses signed Java applet technology and the Java native interface to maintain the SSD. *Table 58* lists the supported operating systems, Java Runtime Environments (JREs) and compatible web browsers. The documentation for the Management utility is found at ***http://www.gnutek.co.uk/giddy.pdf***.

Notes:

1. *The end user is required to have administrator rights to execute the management utility*.
2. The utility is capable of updating the firmware or the programmable gate arrays (“hardware upgrade”).
3. The SSD will log internal events during normal operation. These “messages” are transparent to the host. In the event of an error, the utility is capable of extracting these messages that can be sent to the manufacturer for diagnostic purposes.
4. The user can choose to erase or sanitize the drive.
5. The utility will not permit updating the device with firmware intended for another model or version of the device.

Table 58. *Management Utility Requirements*

Operating System	JRE	Web Browser
Windows 2003	1.5.0	Internet Explorer 6.0+ Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Windows 2000	1.5.0	Internet Explorer 6.0+ Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Windows XP	1.5.0	Internet Explorer 6.0+ Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Windows ME	1.5.0	Internet Explorer 6.0+ Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Linux	1.5.0	Mozilla Firefox 1.4+ Netscape Navigator 7.0+
Solaris	1.5.0	Netscape Navigator 7.0+

Diagnostic Software

The computer or system manufacturer is responsible for providing any diagnostic software or utilities.

REGULATORY COMPLIANCE

MARKING, APPROVALS AND SUPPORTING DOCUMENTATION

The SSD may have the following marks, approvals and documentation as outlined in *Table 59.*

Table 59. *Regulatory Marks and Documentation*

Mark/Approval	Documentation	Mark
CE	Electrical equipment sold in the European Economic Area (EEA) will comply with the requirements of CAN/CSA-C22.2 No. 60950-1-03 and be marked (CE) accordingly.	Yes
FCC	Federal Communications Commission Declaration of Conformity	Yes

RESTRICTION OF HAZARDOUS MATERIALS

STEC Inc. has adopted the RoHS Directive, also known as the Restriction of Hazardous Substances directive. The SSD is compliant with the European Parliament and Council Directive, i.e., assembled with Pb-free or lead-free components and manufacturing processes.

FCC DECLARATION OF CONFORMITY

The FCC (Federal Communications Commission) Declaration of Conformity (DoC) will contain the following:

- Product type and model number
- Marks and countries (e.g., CE, FCC)
- The appropriate technical statement(s) required by the respective regulatory agencies
- STEC name and address
- STEC signature
- List of all applicable standards to which the drive conforms

Radio Frequency Emissions

The SSD has passed radiated emissions testing (10 meter chamber) with a minimum margin of 4dB below the EN55022 radiated emissions limits in all applicable customer platforms, without any required changes to the system platforms.

Emissions testing in a 3 meter chamber for over 1GHz per the FCC limit for Class B was performed up to 2GHz with the -4dB margin relative to the FCC Class B limit.

In preparation for the new CISPR 22 standard change that may go into effect in the year 2007, the drives will pass EMI tests up to the higher frequency of either 6GHz or the fifth harmonic of the highest signal on the drive. This requirement is applicable to all products being qualified after this version is released. The specification limits are listed in *Table 60*.

Table 60. *EMI Specification Limits*

Class B	1 to 3 GHz is 50dB (uV/m) @ 3 m
Class B	3 to 6 GHz is 54dB (uV/m) @ 3 m

Radio Frequency Immunity Requirements

This specification is targeted as part of the design for quality and reliability expectations and is not part of the regulatory requirements. The SSD will meet the following radio frequency immunity requirements:

- 3 V/m over frequency range of 80 MHz to 1 GHz
- The signal will be amplitude modulated with a 1KHz sine wave to a depth of 80%
- Failure criteria: More than 10% throughput degradation

EMI Test Site Correlation

STEC Inc. will only use EMI test sites that are currently correlated with the customer's test facilities. STEC Inc. will contact the customer's engineering staff for the list of approved laboratories.

Verification Samples

STEC Inc. will submit the three worst-case drives used to obtain the emissions test data previously obtained from the customer's test facilities for verification testing. The Regulator Engineer will use these drive samples, and others among those submitted for qualification, for emissions verification in the customer's systems.

Verification Testing

Verification testing will be performed by the customer's Compliance Peripheral Group.

ELECTROSTATIC DISCHARGE (ESD)

The SSD will meet the ESD limits specified in the 61000-4-2 guidelines and the customer's enhanced ESD procedure. The specification will determine whether the contact or air discharge method should be used. Performance degradation is defined as a decreased throughput rate. No data errors are allowed. *Table 61* lists the ESD requirements.

Table 61. *ESD Requirements*

Climatic Conditions		
Ambient Temperature	15^{o}C to 35^{o}C	
Relative Humidity	30% to 60%	
Atmospheric Pressure	86kPa (860 millibar) to 106 kPa (1,060 millibar)	
Voltage Level	Discharge Type	Pass/Fail Performance Criteria
+/-2 kV	Contact	A
+/-4 kV	Contact	B
+/-6 kV	Contact	B
+/-8 kV	Contact	C
+/-2 kV	Air	A
+/-4 kV	Air	A
+/-8 kV	Air	B
+/-12 kV	Air	B
+/-15 kV	Air	C

ACCEPTANCE CRITERIA DEFINITIONS

The following table lists the acceptance criteria definitions for the ESD limits.

Table 62. *Acceptance Criteria Definitions*

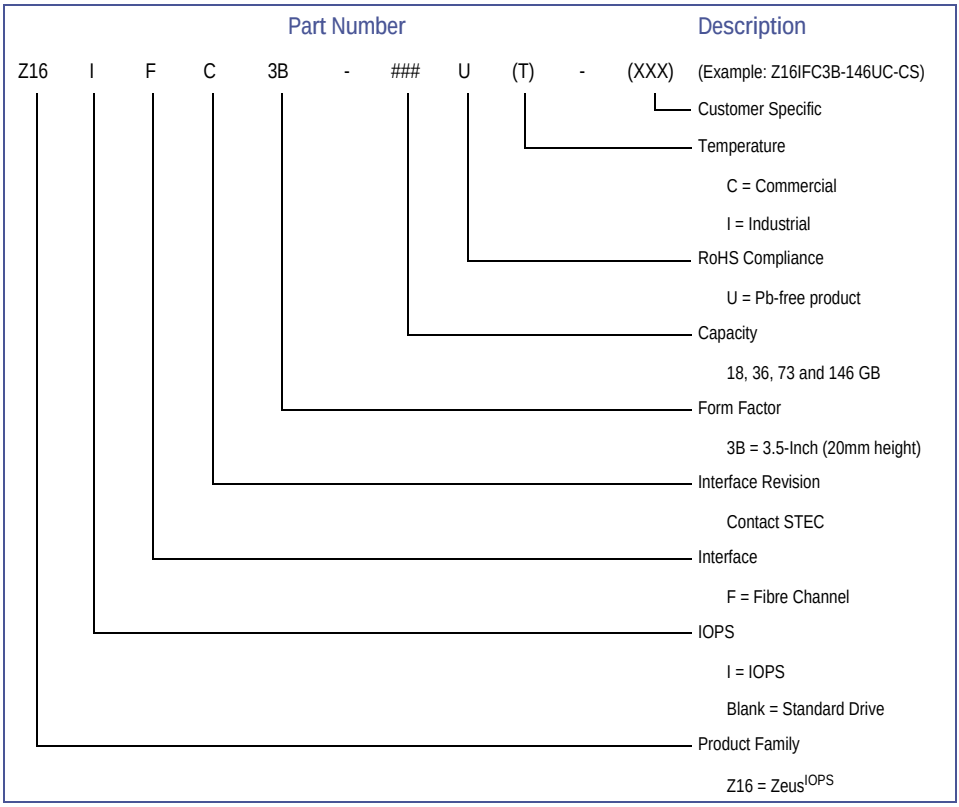
A	The apparatus will continue to operate as intended, i.e., normal unit operation with no degradation of performance.
B	The apparatus will continue to operate as intended after completion of the test. However, during the test, some degradation of performance is allowed, provided there is no data lost or operator intervention to restore apparatus function.
C	Temporary loss of function is allowed. Operator intervention is acceptable to restore apparatus function.
	Note: Hardware failures are not acceptable for any level of the above performance criteria.

CONTACT AND ORDERING INFORMATION

Contact Information.

Telephone:	1-949-260-8345
Fax:	1-949-476-1927
E-mail:	ssd@stec-inc.com

Ordering Information



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CERTIFICATION AND WARRANTY

FCC Declaration of Conformity

The Solid State Drive carries the FCC-Mark in accordance with related Federal Communications Commission (FCC)–USA directives. This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Re-orient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment to an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/television technician for help.

Modifications made to this device that are not approved by STEC may void the authority granted to the user by the FCC to operate this equipment.

Limited Warranty

STEC Inc., Solid State Drives are warranted against defects in material and workmanship, and will operate in substantial conformance with their respective specifications under normal use and service for a period of five (5) years from the date of shipment. Subject to the conditions and limitations set forth below, STEC will, at its own option, either repair or replace any defective SSD Product that proves to be defective by reasons of improper workmanship or materials, if buyer notifies STEC of such failure within the stated warranty period. Products repaired or replaced during the applicable warranty period shall be covered by the foregoing warranties for the remainder of the original warranty period or ninety (90) days from the date of reshipment, whichever is longer. Parts used to repair products or replacement products may be provided by STEC on an exchange basis, and will be either new or refurbished to be functionally equivalent to new.

STEC INC. DISCLAIMS ALL OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WITH RESPECT TO ITS PRODUCTS AND ANY ACCOMPANYING WRITTEN MATERIALS. FURTHER, STEC INC. DOES NOT WARRANT THAT SOFTWARE WILL BE FREE FROM DEFECTS OR THAT ITS USE WILL BE UNINTERRUPTED OR REGARDING THE USE, OR THE RESULTS OF THE USE OF THE SOFTWARE IN TERMS OF CORRECTNESS, ACCURACY, RELIABILITY OR OTHERWISE.

STEC Inc. is not responsible for updates or functionality of third-party software. Software is provided with notices and/ or licenses from third parties which govern your use.

Modifications

Any changes or modifications made to this device that are not expressly approved by STEC Inc. will void the user's warranty. All wiring external to the product should follow the provisions of the current edition of the National Electrical Code.

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